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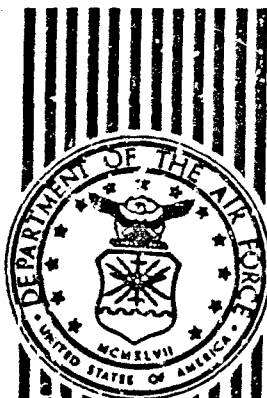
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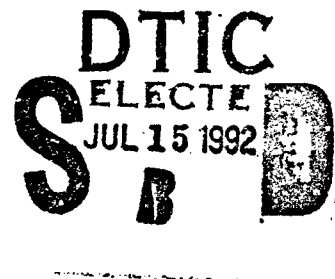
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**FULL-SCALE INCINERATION SYSTEM
TRIAL BURNS AT THE NAVAL BATTALION
CONSTRUCTION CENTER, GULFPORT,
MISSISSIPPI - VOL II:
PART 1**

D. J. HALEY, R. W. THOMAS

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FINAL REPORT

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19. ABSTRACT (Continue on reverse if necessary and identify by block number) This technical report is divided into eight volumes. This portion of the report comprises Volume III, which is further divided into two parts, including the appendixes. This volume describes the tests conducted on a 100 ton/day mobile incinerator that was used to process soil contamination with the constituents of Herbicide Orange, namely 2,4,5-T, 2,4-D, and trace quantities of dioxin. The purpose of the tests was to determine if the incinerator could satisfy requirements of the Resource Conservation and Battalion Center in Gulfport, Mississippi. This volume provides specific details concerning the planning efforts and data results from the tests. Project managers and field engineers responsible for planning and implementation of hazardous waste remedial actions should find the information in this report to be very useful.					
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EXECUTIVE SUMMARY

The Full-Scale Mobile Rotary Kiln Incineration System Demonstration Project was conducted at the Naval Construction Battalion Center (NCBC) in Gulfport, Mississippi, between September 1986 and February 1989. This research program was conducted as part of the United States Air Force Installation Restoration Program.

The overall goal of the research program was to demonstrate the effectiveness and reliability of a 100 ton/day rotary kiln incinerator in processing soil contaminated with dioxins and other hazardous constituents of Herbicide Orange.

The research program was divided into three phases. The first phase, the Verification Test Burn, demonstrated the effectiveness of the 100 ton/day rotary kiln incinerator to clean soil contaminated with dioxin and other constituents of Herbicide Orange. That phase is reported in Reference 1.

The second phase demonstrated the ability of the incinerator to meet the requirements of the Resource Conservation and Recovery Act (RCRA), which specifies that the incinerator must meet or exceed a destruction and removal efficiency of 99.9999 percent. This second phase is the subject of this report.

The third phase occurred during continual operation and demonstrated the reliability and maintainability of the incinerator. That information is extensively reported in References 2 through 6.

The third Trial Burn demonstrated the ability of the incinerator to process hazardous waste that contained principal organic hazardous constituents (POHC) that were more difficult to destroy than 2,3,7,8-tetrachlorodibenzo-p-dioxin, which is the most hazardous constituent found in the native NCBC soil.

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Hexachloroethane (HCE) and 1,2,4-trichlorobenzene (TCB) were used as the two surrogate POHCs. Clean builders sand was used as a surrogate soil matrix in lieu of native soil.

Three tests were completed at a nominal feed rate of 5.3 tons/hour. The surrogate POHC concentration in the sand was nominally 2500 ppm. Destruction and removal efficiencies of 99.99997, 99.999979, and 99.99997 percent were demonstrated. Higher DREs might have been possible if lower analytical detection limits were used.

Although six tests were planned, only three were actually completed. Weather and sampling problems forced the cancellation of the other three tests.

This report describes the equipment and procedures used to conduct the tests, in addition to the detailed results of the trial burn. The rationale for the various technical and managerial decisions is given.

Following the tests, a substantial amount of information was requested by and transmitted to EPA Region IV, the regulatory agency. That information is presented and discussed.

Conclusions and recommendations drawn may assist other persons needing to perform a trial burn in support of a hazardous waste remedial action.

The Air Force Engineering and Services Center provided the funding and principal management for the program. Project management services and technical oversight were provided by the Idaho National Engineering Laboratory, EG&G Idaho, Inc. Sampling services were provided by Versar, Inc. of Springfield, Virginia. Analytical Services were provided by International Technology Analytical Services of Knoxville, Tennessee. The incinerator used was owned and operated by ENSCO Environmental Services of Little Rock, Arkansas.

PREFACE


This report was prepared by EG&G Idaho, Inc., P. O. Box 1625, Idaho Falls, ID 83415, under Job Order Number (JON) 2103 9027, for the Air Force Engineering and Services Center, Engineering and Services Laboratory, Tyndall Air Force Base, Florida 32403-6001.


This report summarizes work done between January 1987 and May 1987. Major Terry Stoddart and Major Michael L. Shelley were the AFESC/RDVS Project Officers.

The information contained in this volume describes the events, the planning efforts, and the data results of a trial burn conducted on a 100 ton/day mobile incinerator that was used to process soil contaminated with constituents of herbicide orange. This volume is subdivided into two parts; Part 1 contains the final report on the trial burns, and Appendix A. Part 2 contains Appendix B-H. Volumes I and II through IV through VIII describe the incinerator operations, the soil excavation activities, and the additional testing required by the Environmental Protection Agency.

This report has been reviewed by the Public Affairs Office (PA) and is releasable to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.


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ACRONYMS

AFESC	Air Force Engineering and Services Center
APR	Air-purifying respirator
ASTM	American Society for Testing and Materials
AWFSO	Automatic waste feed shutoff
BNA	Base/neutral/acid
CDC	Centers for Disease Control
CLP	Contract Laboratory Program
DAS	Data Acquisition System
DOD	Department of Defense
DOE	Department of Energy
DRE	Destruction and Removal Efficiency
ENSCO	Environmental Services Company
ENT	Effluent Neutralization Tank
EPA	Environmental Protection Agency
GC/MS	Gas Chromatography/Mass Spectrometry
HEPA	High-Efficiency Particulate Arresting
HO	Herbicide Orange
HRGC	High-Resolution Gas Chromatograph
HRMS	High-Resolution Mass Spectrometry
HSWA	Hazardous and Solids Waste Amendments
INEL	Idaho National Engineering Laboratory
ITAS	International Technologies Analytical Services
JI	Johnston Island
K-D	Kuderna-Danish
LRMS	Low-Resolution Mass Spectrometry
M5	Method 5
MMS	Modified Method 5
MWP-2000	Mobile Waste Processor-2000
NCBC	Naval Construction Battalion Center
OEHL	Occupational and Environmental Health Laboratory

ACRONYMS
(CONCLUDED)

PAPR	Powered Air-Purifying Respirator
PIC	Partially Incomplete Combustion Products
POHC	Principal Organic Hazardous Constituent
POTW	Publicly-Owned Treatment Works
PPB	Parts per billion
PPM	Parts per million
PUF	Polyurethane Foam
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RD&D	Research, Development, and Demonstration
REs	Removal Efficiencies
SCBA	Self-Contained Breathing Apparatus
SCC	Secondary Combustion Chamber
TDU-GC	Thermal Decomposition Unit-Gas Chromatograph
TLV	Threshold Limit Value
USAF	U.S. Air Force
VOA	Volatile Organic Analysis
VOST	Volatile Organic Sampling Train
WBG	Wet Bulb Globe Temperature

SECTION I

INTRODUCTION

A. OBJECTIVE

The purpose of the Naval Construction Battalion Center (NCBC) Demonstration Project was to demonstrate the reliability, maintainability, and cost effectiveness of a mobile rotary kiln incinerator system for soil cleanup and restoration at a Herbicide Orange (HO)-contaminated site. The mobile waste incineration system, Model MWP-2000, manufactured and operated by ENSCO Environmental Services Company (ENSCO) of Little Rock, Arkansas, was selected for the project. The selected location is a former HO storage site at the NCBC in Gulfport, Mississippi. This program is under the sponsorship of the United States Air Force Engineering and Services Center (AFESC), Tyndall Air Force Base, Florida. Technical and project management services were provided by EG&G Idaho, the prime Department of Energy (DOE) contractor at the Idaho National Engineering Laboratory (INEL).

The field demonstration of the program was organized into three phases to facilitate the interactions with the U.S. Environmental Protection Agency (EPA) for the research, development, and demonstration (RD&D) permit. Those phases were:

1. Preoperational test burns to verify technical performance and provide data for a range of soil feed rates.
2. Trial burn to ensure conditions of Resource Conservation and Recovery Act (RCRA) permit can be met.
3. Continuous operation to provide reliability and maintainability data, and demonstrate cost-effectiveness based upon an actual site remediation.

This report discusses the activities associated with the second phase conducted during May 1987. The first phase, conducted in December 1986, is reported in Reference 1. The subsequent reports for the third phase are reported in Reference 2 through 6.

Specific objectives of the trial burn were to:

1. Demonstrate that the Mobile Waste Processor-2000 (MWP-2000) incinerator system can destroy organic compounds that are more difficult to incinerate than 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and other hazardous constituents of HO.
2. Provide data to support issuance of Federal Permits under RCRA of 1976, as amended by the Hazardous and Solids Waste Amendments (HSWA) of 1984, that would allow operation of the MWP-2000 incinerator system to destroy polychlorodibenzo-p-dioxins (PCDDs), polychlorodibenzofurans (PCDFs), and most other RCRA-listed substances.

B. BACKGROUND

HO is primarily composed of two compounds, 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) and various esters of these two compounds. HO was sprayed as a defoliant in Vietnam during the 1960s and at Eglin Air Force Base, Florida, between 1962 and 1970 (References 7 and 8). The NCBC served as a temporary storage site for the HO-filled drums while awaiting loading of those drums for ocean shipping to Vietnam. Drum storage at the site varied between 6 and 18 months. Early in 1970, the herbicide 2,4,5-T was reported to be a teratogen in mice and rats (Reference 9). More specifically, studies identified an unwanted byproduct, 2,3,7,8-TCDD, which was contained in 2,4,5-T, as the reason for the teratogenic effects (Reference 10). The Department of Defense (DOD) discontinued the use of HO in 1970 (Reference 11). At that time, 850,000 gallons of HO were in storage at NCBC, and 1,370,000 gallons located in South Vietnam were shipped to Johnston Island (JI) in the Pacific Ocean for storage (Reference 12).

During the summer of 1977, the entire H₀ stockpile was disposed at sea by high-temperature incineration (Project PACER H₀, Reference 12). However, spills during the storage and handling of H₀ left the soil at the storage area contaminated with dioxin. The Air Force Logistics Command Plan and EPA permits for the disposal of H₀ committed the Air Force to a follow-up storage site reclamation and environmental monitoring program (Reference 12). Immediately following the at-sea incineration, the U.S. Air Force Occupational and Environmental Health Laboratory (USAF/OEHL) initiated site monitoring studies of chemical residues in nearby soil, drainage water, and drainage ditch sediment at the former NCBC H₀ storage site (References 12 and 13).

1. Restoration Criteria

Of the PCDD/PCDF isomers, the 2,3,7,8-TCDD isomer is considered to be the most toxic to man (Reference 14). This toxicity may be 10 times as toxic as the next isomer within this group (Reference 15). The Centers for Disease Control (CDC) of the U.S. Department of Health and Human Services in Atlanta, Georgia, studied the risks of various concentrations of 2,3,7,8-TCDD in soil and concluded that residual soil levels at or above 1 part per billion (ppb) of 2,3,7,8-TCDD in residential areas represent a level of concern (Reference 16). In certain commercial areas, higher levels in the soil may represent an acceptable risk to nonoccupationally exposed individuals. However, the CDC also concluded that, on ranges and pastures, lower concentration levels in the soil may still be of concern since the 2,3,7,8-TCDD accumulates in the tissues of grazing cattle and routing swine (Reference 16).

In a November 7, 1986, Federal Register notice (Reference 17), EPA promulgated a standard for land disposal of PCDD/PCDF containing waste material. The standard required that these constituents (i.e., all isomers of tetra-, penta-, and hexachlorodibenzo-p-dioxins and dibenzofurans) be below a 1 ppb limit in the waste before being land-disposed. Furthermore, wastes having concentrations that meet or exceed this limit may be treated in accordance with the criteria for incineration (40 CFR 264.343 and 265.352) and thermal treatment (40 CFR 265.370) for dioxins. Criteria

that will be applied for future full-scale restoration projects will depend on regulatory requirements in effect at the time and the cost-effectiveness of the technologies being considered.

2. Permit Performance Criteria

EPA requires that incinerators burning hazardous waste must meet three performance standards. As specified in 40 CFR 264.343, these standards relate to: (a) destruction and removal efficiency (DRE) of each principal organic hazardous constituent (POHC) for wastes designated as F020, F021, F022, F023, F026, or F027, (b) a limit on HCl emissions from the stack, and (c) a limit on particulate matter emitted from the stack. In terms of numerical requirements, these standards are:

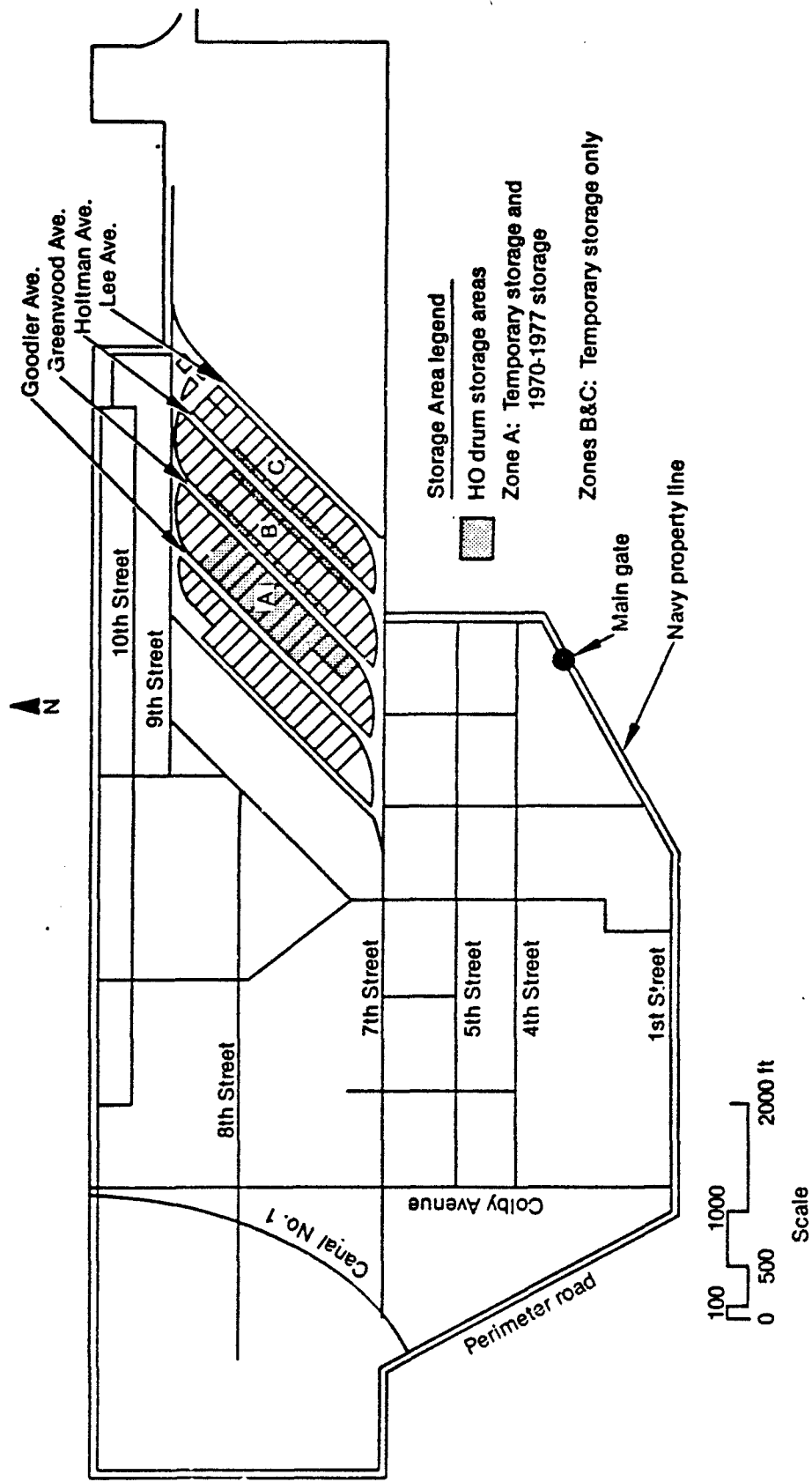
- a. The DRE for each POHC must meet or exceed 99.9999 percent, calculated on a mass rate basis.
- b. The concentration of particulate in the system's stack gas must be below 180 mg per dry standard cubic meter. (This concentration must be corrected to 7 percent O₂, for reporting consistency.)
- c. The total stack emission of chloride (expressed as HCl) must be less than 1.8 kg per hour.

The DRE calculations are based on the mass feed rate of a contaminant compound into the incinerator and the mass emission rate of that compound from the stack. More specifically, the expression is:

$$\text{DRE (percent)} = \frac{(W_{in} - W_{out})}{W_{in}} \times 100 \quad (1)$$

where

W_{in} = mass feed rate of POHC in the waste stream feeding the incinerator.



7-3327

Figure 2. NCBC and location of former herbicide orange storage site.

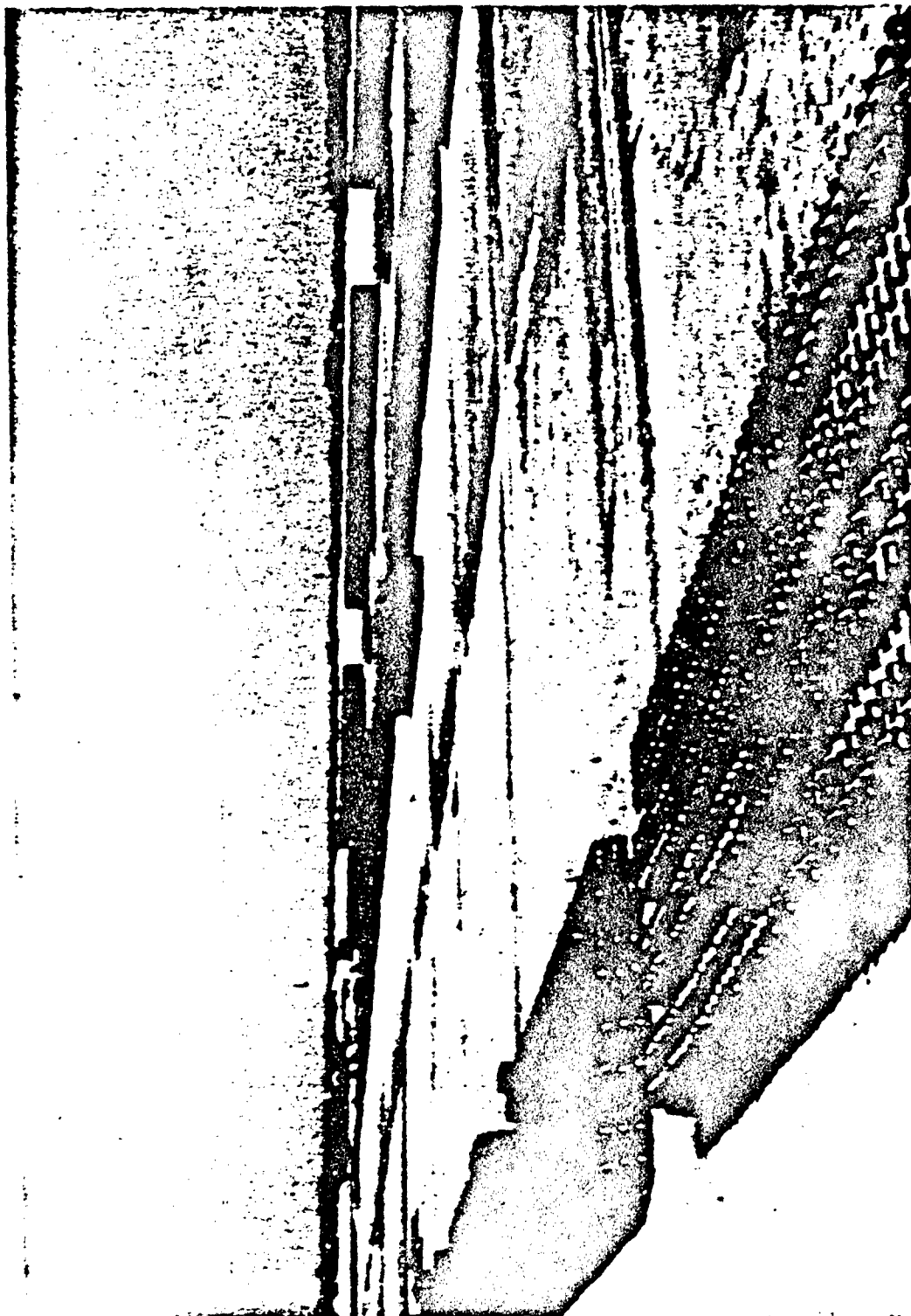


Figure 3. H0 drum stacks in NCBC storage Zones B and C.

W_{out} = mass emission rate of the same POHC present in the exhaust emissions prior to release to the atmosphere.

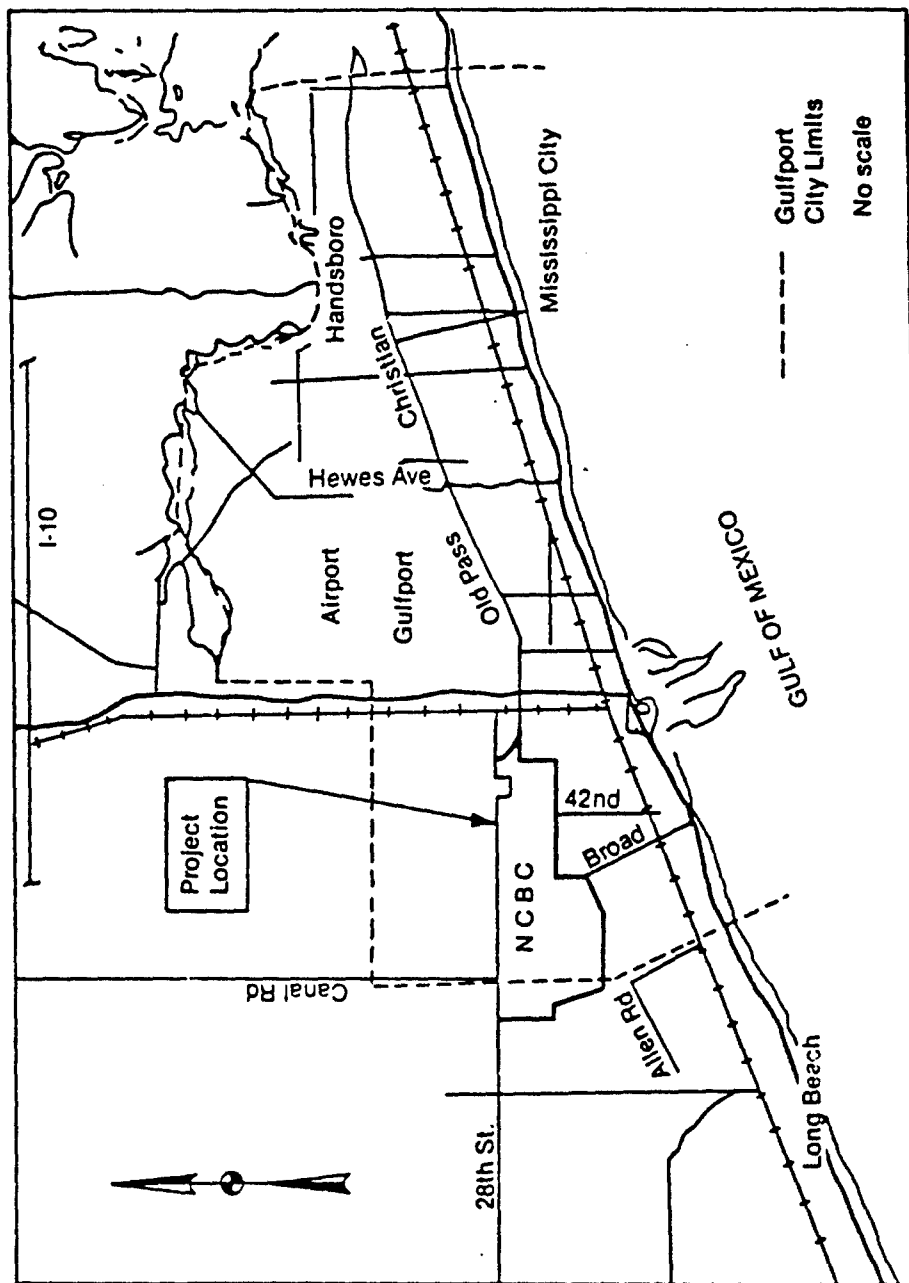
3. Storage Site Location

NCBC is a fenced, limited-access military installation (Figure 1). It is a land area of several square miles located approximately 2 miles from the Gulf of Mexico and is approximately 20 feet above sea level. The indigenous soil is sand to sandy loam, intermixed with some clay.

Approximately 18 acres at NCBC served as an H₀ storage site. During the temporary storage phase, the H₀ drums were stacked within three zones (A, B, and C), shown as shaded areas in Figure 2. The stacks of drums in Zones B and C covered 40-foot by 1200-foot strips along the indicated roadways (Figure 3). The storage of filled drums during 1970-1977 occurred only in Zone A. Because of the arrangement of the drums, approximately 31 acres of land were left unusable. Approximately 30 years ago, the storage site was stabilized with Portland Cement. The stabilized soil provided a hardened storage area for heavy supplies and equipment. Over the years, additional fill materials (shell, rock, soil, asphalt, and tar) were added to the storage area, providing a cover up to several inches over the cement-stabilized soil. During 1980, retention basins were constructed on the storage site to prevent migration offsite of dioxin-contaminated soils by surface runoff. Figure 4 provides an overview of the site, primarily Zone A, after the drums were removed.

4. Previous NCBC Incinerator Testing

Five verification test burns were conducted with the MWP-2000 incinerator system during December 1986, processing 100 tons of H₀-contaminated soil under an RD&D permit issued by EPA Region IV. This permit, shown as an appendix in Reference 1, continued to apply during the trial burn testing. As a result of the trial burn data and other identified changes, the RD&D permit was revised and reissued before the full-scale soil restoration operation.



5-3539

Figure 1. NCBC vicinity map.



Figure 4. Overview of the NCBC site Zone A after removal of the H0 drums.

All verification test burns achieved the AFESC goal that the treated soil PCDD/PCDF congener sum (tetra, penta, and hexa) be less than 1.0 ppb. Analytical results showed congener sums that ranged between 0.009 and 0.021 ppb, which were well below the goal (Reference 1). The incinerator operating conditions ranged as follows for the five test burns.

<u>Parameter</u>	<u>Range</u>
Soil feed rate	2.8 - 6.3 ton/hr
Kiln temperature	1355 - 1645°F
Secondary combustion chamber temperature	2097 - 2174°F

Calculated Removal Efficiencies (REs) for the treated soil ranged as follows for critical constituents during the five test burns.

<u>Constituent</u>	<u>Range of Removal Efficiency (percent)</u>
2,3,7,8-TCDD	99.9921 - 99.9966
Total TCDD	99.9952 - 99.9984
2,4-D	99.9130 - 99.9994
2,4,5-T	99.9957 - 99.9998

In most cases these REs are lower bounds because detection limits were used for the treated soil. The actual removal efficiency was probably much higher. The results showed that the incinerator process can effectively restore the soil.

The permit performance criteria listed in Section I.B.2 were part of the RD&D permit for the MWP-2000 incinerator operation at NCBC. EPA Region IV had previously agreed that a RCRA trial burn to demonstrate 99.9999 percent DRE would not be necessary for the MWP-2000 unit located at NCBC. That agreement was made on the premise that an identical MWP-2000 incinerator located in El Dorado, Arkansas, had already demonstrated compliance with the 99.9999 percent DRE requirement. The Verification Test Burns at NCBC in December 1986 were only intended to demonstrate to the

EPA that the MWP-2000 could process native NCBC soil without producing hazardous effluents.

The MWP-2000 incinerator located in El Dorado, Arkansas, underwent an RCRA trial burn in the spring of 1986. In late autumn, before the December 1986 verification test burn at NCBC, EPA Region VII notified ENSCO that the RCRA trial burn at El Dorado failed to demonstrate the required 99.9999 percent DRE. ENSCO did not notify the Air Force, EG&G Idaho, or EPA Region IV of this shortcoming. As a result, the verification tests proceeded as planned and achieved the Air Force goal to demonstrate that no hazardous effluents would be released when processing native NCBC soil.

During the verification test burns, compliance with two of the three criteria was demonstrated: the limits on HCl and particulate matter emissions from the stack. The DRE of 2,3,7,8-TCDD could not be demonstrated by the process because the dioxin concentration in the HO-contaminated soil was not sufficiently high to be able to calculate a DRE meeting the EPA limit of six nines (99.9999) in 40 CFR 264.343(a). No 2,3,7,8-TCDD was detected in the stack gas samples, and high-resolution mass spectrometry (HRMS) was used to achieve lowest possible detection levels ($0.22-0.32 \mu\text{g}/\text{m}^3$); four nines were demonstrated ranging from 99.9968 to 99.9985 percent. DREs of six nines were demonstrated for the herbicides 2,4-D and 2,4,5-T on at least one test burn. Because of its higher initial concentrations in the HO-contaminated soil and lower detection level (factor of 10), the DRE results were better for 2,4,5-T than for 2,4-D with a range of 99.9968 to 99.9999 percent. Two test burns met six nines; however, EPA recommends that three test burns should meet this POHC performance requirement (Reference 18). The 2,4-D range was 99.9736 to 99.9999 percent, with one test burn having a DRE of six nines.

On January 30, 1987, a preliminary data package from the verification test burns was submitted to EPA Region IV for review. That data package included treated soil data and stack effluent concentrations. A revised data package was submitted to Region IV on February 13, 1987. Submittal of

DRE calculations followed on February 23, 1987, to supplement the basic data package. A final data package, compiling all data within one document, was hand-carried to Region IV on March 16, 1987.

After conferring with EPA Region IV, it was determined that the verification test burn results were not sufficient to satisfy the POHC performance requirement, and a trial burn of the MWP-2000 incinerator system would be required to demonstrate this capability before full-scale soil restoration could proceed at the NCBC. Because the concentrations of contaminating constituents were not sufficiently high to achieve the desired sensitivity, a surrogate feed would be necessary. Surrogate selection is discussed next.

5. POHC Selection Rationale Overview

Two POHCs were selected as surrogates for the HO-contaminated soil: hexachloroethane (HCE) and 1,2,4-trichlorobenzene (TCB). The selection rationale for each is summarized below. A detailed discussion is presented in Section III.C.

Hexachloroethane was selected as a POHC, primarily as a result of its low heat of combustion value (0.47 kcal/gram) (Reference 18). Of the hazardous constituents listed in Appendix VIII of 40 CFR 261, HCE is ranked third on the EPA's list ranking the incinerability of organic hazardous constituents on the basis of heat of combustion (Reference 18). HCE is the highest ranked solid compound by this same system. HCE is a solid below 367°F and has a low vapor pressure that reduces fugitive emissions and provides maximum flexibility during waste preparation.

1,2,4-trichlorobenzene was selected as the second POHC because this compound has a heat of combustion value (3.4 kcal/gram) (Reference 18) that is very close to TCDD (3.43 kcal/gram) and has favorable physical and chemical properties. The relatively low toxicity and low vapor pressure were also considered in the 1,2,4-TCB selection.

Another advantage of using these two compounds is that both HCE and 1,2,4-TCB can be detected by using the same analytical procedure, which is EPA Method 8270 (Reference 19).

6. Regulatory Authorizations and Public Participation

The RD&D permit authorized by EPA Region IV before the verification test burns continued to apply for the trial burn. This permit is shown as an appendix to Reference 1. However, following review of the final data package from the verification test burns, EPA specified that there would be no further incineration of HO-contaminated soil at NCBC until the MWP-2000 incinerator system had successfully completed a trial burn using the surrogate approach (Appendix A, Exhibit 1).

A draft test plan for the trial burn using the surrogate approach was prepared (Reference 20) and submitted on March 17, 1987 to EPA Region IV for review and authorization to proceed. On March 27, 1987, EPA Region IV responded with numerous questions that required resolution before testing (Appendix A, Exhibit 2). On April 17, 1987, the Air Force submitted a revised trial burn plan (Appendix A, Exhibit 3). Following receipt of verbal comments from EPA Region IV, revised pages to the test plan were submitted on April 27, 1987 (Appendix A, Exhibit 4). Authorization to proceed with the MWP-2000 incinerator system trial burn at the NCBC, using surrogates HCE and 1,2,4-TCB mixed with clean sand, was granted by EPA Region IV on May 1, 1987 (Appendix A, Exhibit 5).

Public notification and participation in the RD&D permit process and subsequent preparation for the verification test burns are discussed in Reference 1. Before the trial burn on the evening of April 27, 1987, the AFESC held a public information meeting at the Westside Community Center in Gulfport, Mississippi. Advance notice of the meeting and general background information were given in a news article that appeared in Gulfport's The Sun Herald on April 26, 1987. According to a followup news article that appeared in the The Sun Herald on April 28, 1987, the meeting was attended

by a small group of people from the public that included the local state senator. Representatives from the AFESC, NCBC, EPA, and the Mississippi Bureau of Pollution Control also attended. Following the Air Force's presentation, representatives from the public group apparently remained skeptical and wanted assurances that the dioxin would not escape from the contaminated site, according to the news article. An additional news article that appeared in a Gulfport weekly, The Star Journal, on April 30, 1987, reported on the information meeting.

The publicly-owned treatment works (POTW) permit issued by the Mississippi Bureau of Pollution Control before the verification test burns remained in effect for the trial burns. A copy of the POTW permit is an appendix to Reference 1.

C. SCOPE/APPROACH

The scope of this report is to document the results of the ENSCO MWP-2000 incinerator system trial burn. The approach was to conduct a field demonstration with a full-scale unit at the NCBC site. A suitable quantity of clean soil (about 300 tons) mixed with two surrogate organic compounds was treated by the incinerator process. The incinerator operating parameters were varied to demonstrate system performance acceptability and repeatability. Versar, Inc. of Springfield, Virginia, performed all sampling activities. International Technique Analytical Services (ITAS) of Knoxville, Tennessee, provided analytical services. EG&G Idaho provided overall technical and project management. An AFESC representative acted as a liaison with the involved federal and state agencies.

This report encompasses two parts. Part 1 documents the results of the MWP-2000 incinerator system trial burns at NCBC. The second part consists of appendixes. For the reader's convenience, a complete list of appendixes is contained in the Table of Contents.

SECTION II

TEST EQUIPMENT TECHNOLOGY

This section briefly describes the MWP-2000 incinerator system components and operation. A more detailed description can be found in an appendix of Reference 1.

A. GENERAL DESCRIPTION

The ENSCO incinerator system (Mobile Waste Processor--MWP-2000) was designed and fabricated by ENSCO at the White Bluff, Tennessee, manufacturing facility. The MWP-2000 incinerator is a modular system designed to destroy and detoxify solid, semisolid, and/or liquid wastes. Most of the components of the system are installed on flatbed semi-trailers, platforms, or skids to facilitate the movement of the system from location to location to perform onsite cleanup of contaminated sites.

Figure 5 shows an overall view of the MWP-2000 incinerator system as it was installed at the NCBC site. Figure 6 is a system flow schematic. Principal components of the unit are:

- Waste feed system
- Rotary kiln with outlet cyclones
- Secondary combustion chamber (SCC)
- Air pollution control train consisting of
 - Effluent neutralization unit

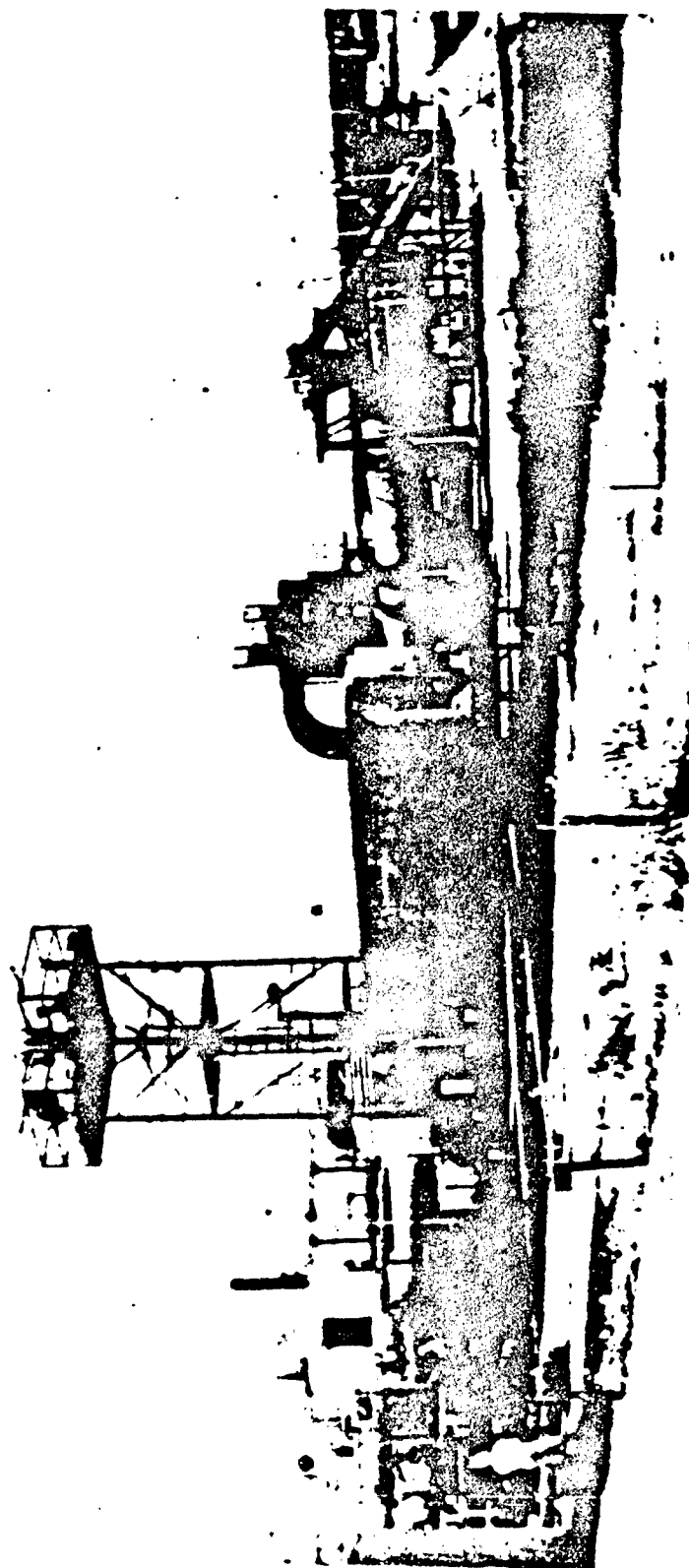


Figure 5. Overall view of MWP-2000 incinerator system.

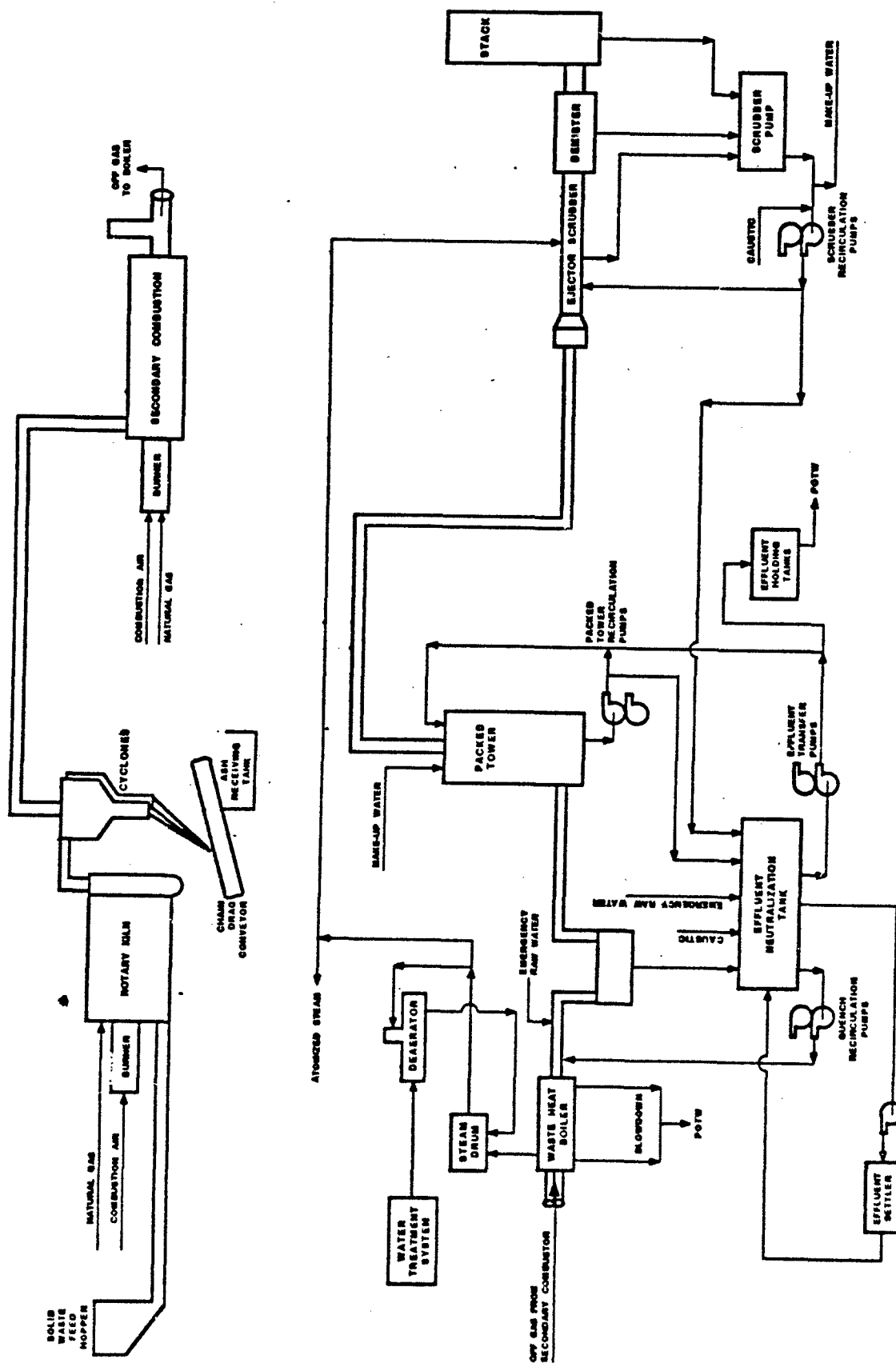


Figure 6. Schematic flow diagram of MWP-2000 incinerator system.

- Packed tower
- Ejector scrubber, demister, and stack.

The auxiliary components of the unit are:

- Waste heat boiler and steam drum
- Boiler water treatment unit
- Ash removal unit
- Effluent settling unit
- Effluent holding tanks.

B. PROCESS DESCRIPTION

1. Feed

After soil has been excavated, it is stockpiled near the incinerator. A front-end loader then transfers the soil to a weigh hopper/shredder unit (Figure 7). The soil is then weighed and shredded into small pieces, which then drop onto a covered feed conveyor that transfers the soil to the feed hopper (Figure 8).

Once the soil falls into the feed hopper, a rotary auger moves the soil into the rotary kiln (Figure 9). Figure 10 shows the 10-inch diameter auger in the process of feeding soil.

2. Primary Incineration

The rotary kiln is primarily designed to burn or detoxify hazardous waste. Detoxification occurs by thermal desorption of organics

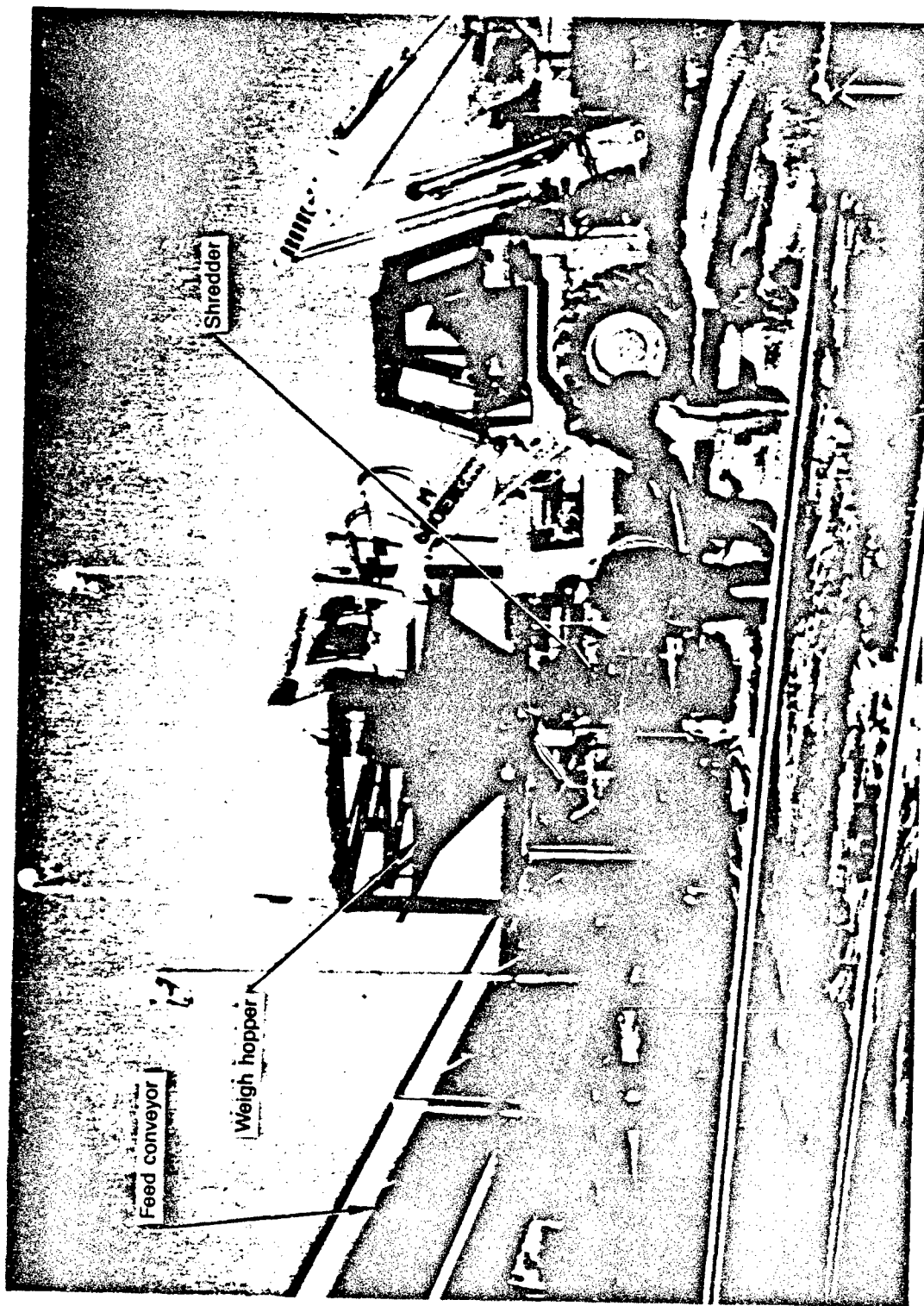
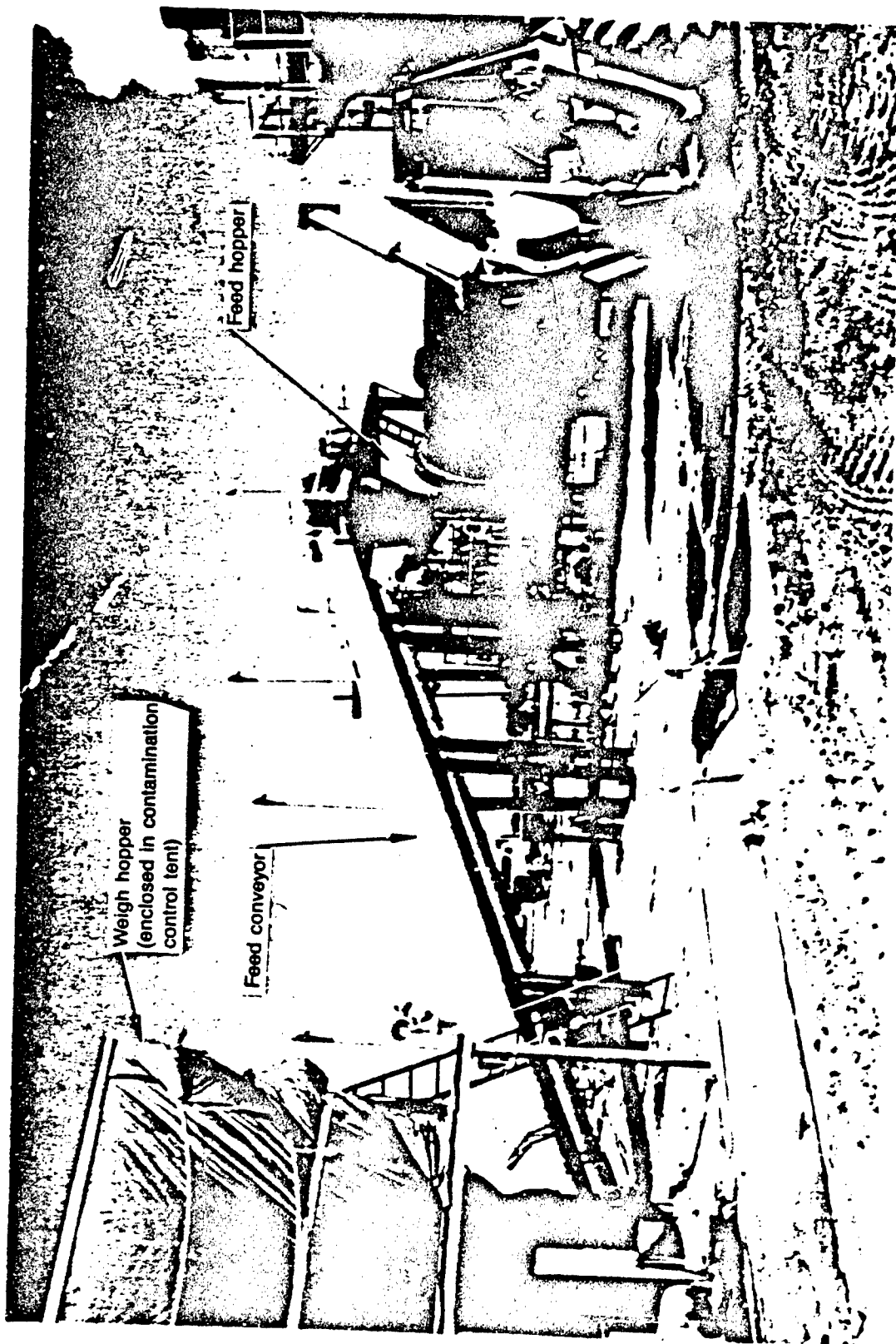


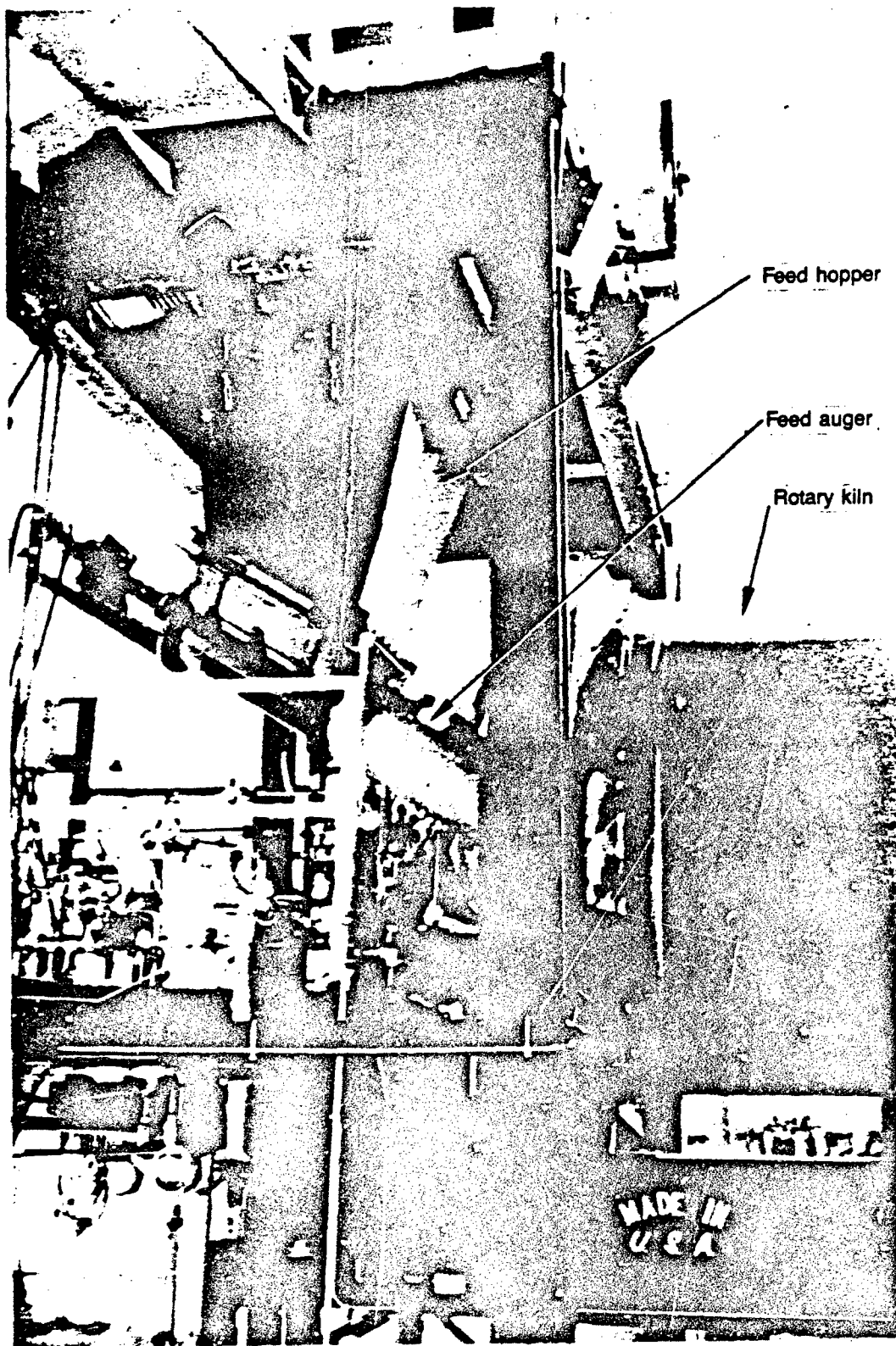
Figure 7. View of weigh hopper, shredder, and covered conveyor.

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Figure 8. View of covered conveyor and feed hopper.



9-8816

Figure 9. External view of feed hopper bottom and auger feed to kiln.



Figure 10. View of rotary auger inside feed hopper.

from the solid waste. Because of the high temperatures, however, the kiln will combust and destroy some of those desorped organics. Additionally, wastewater and other liquid materials can be processed by injection through nozzles located near the burner.

The rotary kiln, shown in Figure 11, is approximately 30-feet long and sits on top of a flatbed tractor trailer. The kiln is inclined at approximately 2 degrees and is rotated by a hydraulically powered gear trunnion mechanism (Figure 12).

The kiln burner is rated at 14 million Btu/hour and can use a variety of fuels such as fuel oil, propane, or natural gas; this project used natural gas. The outlet gas temperatures typically range from 1350 to 1800°F. The solids residence time within the kiln varies from 20 to 40 minutes, depending upon kiln rotation speed and angle of inclination.

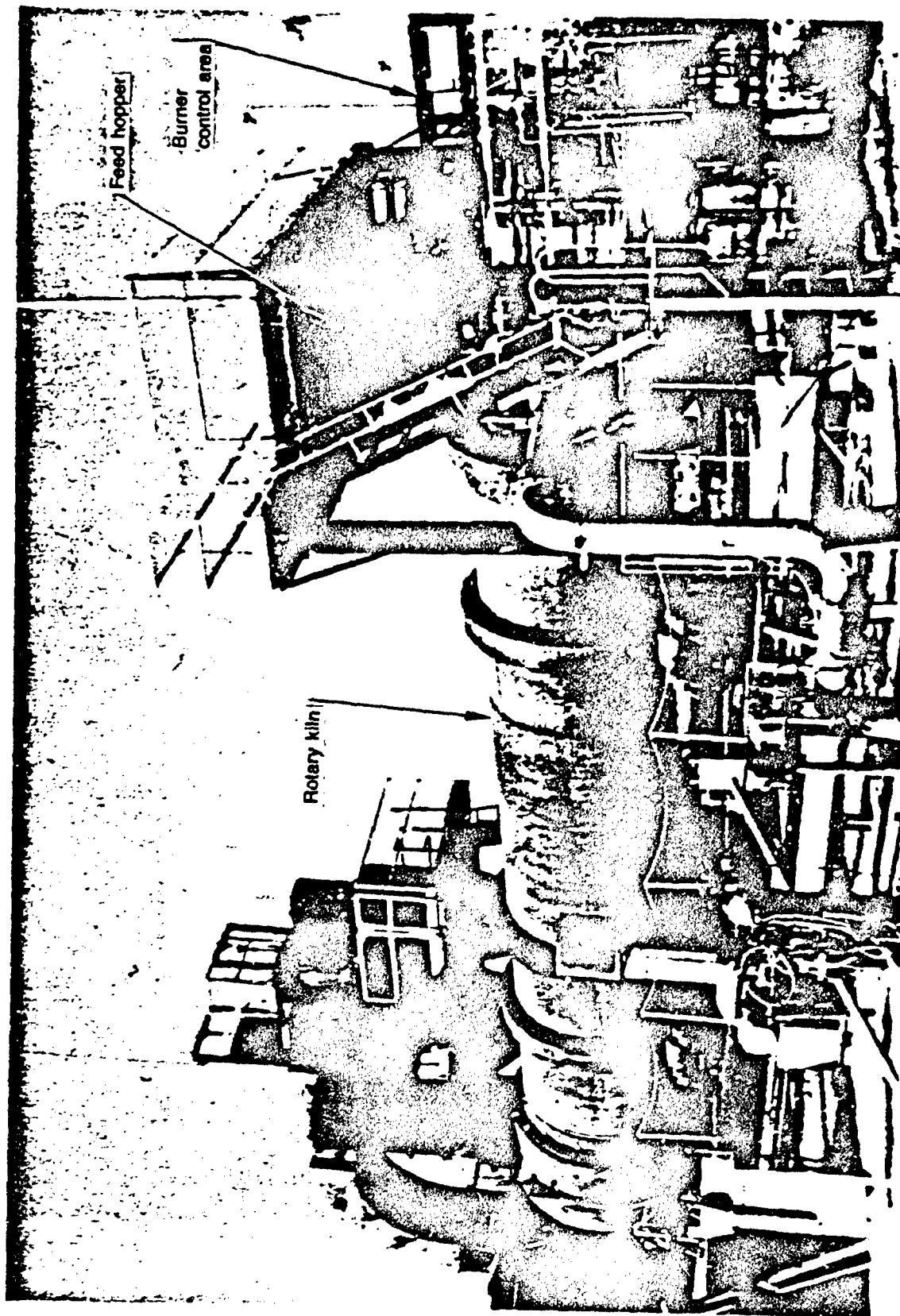
3. Ash Collection

At the gas outlet of the kiln, the solids fall into an ash quench while the gases rise up and flow into the cyclone particle separators. The ash quench is a rectangular water tank which catches the processed soil. The ash quench and cyclones are shown in Figure 13.

At the bottom of the ash quench is an ash-drag conveyor that removes the process ash and places it into an ash bin (Figure 14). During the verification tests burns, a rolloff box (Figure 14) was used. The ash quench also serves as a seal between the process gases and the outside environment.

4. Gas Stream Particulate Separation

The hot process gases flow from the kiln upward to the cyclone separators, which remove the heavy particulate from the gas stream. The



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Figure 11. View of trailer-mounted rotary kiln.

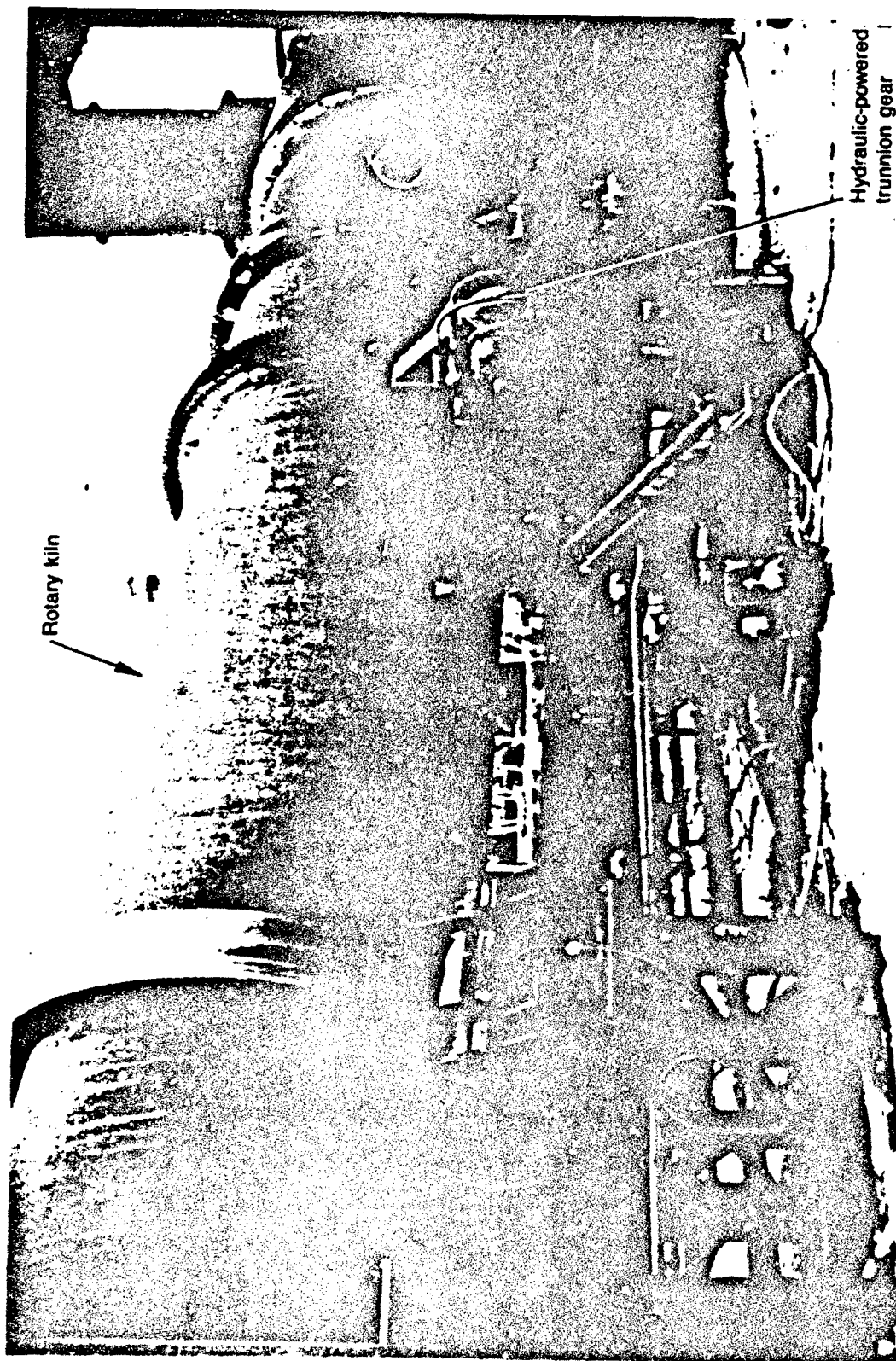


Figure 12. View of kiln rotary drive mechanism and trunnion supports.

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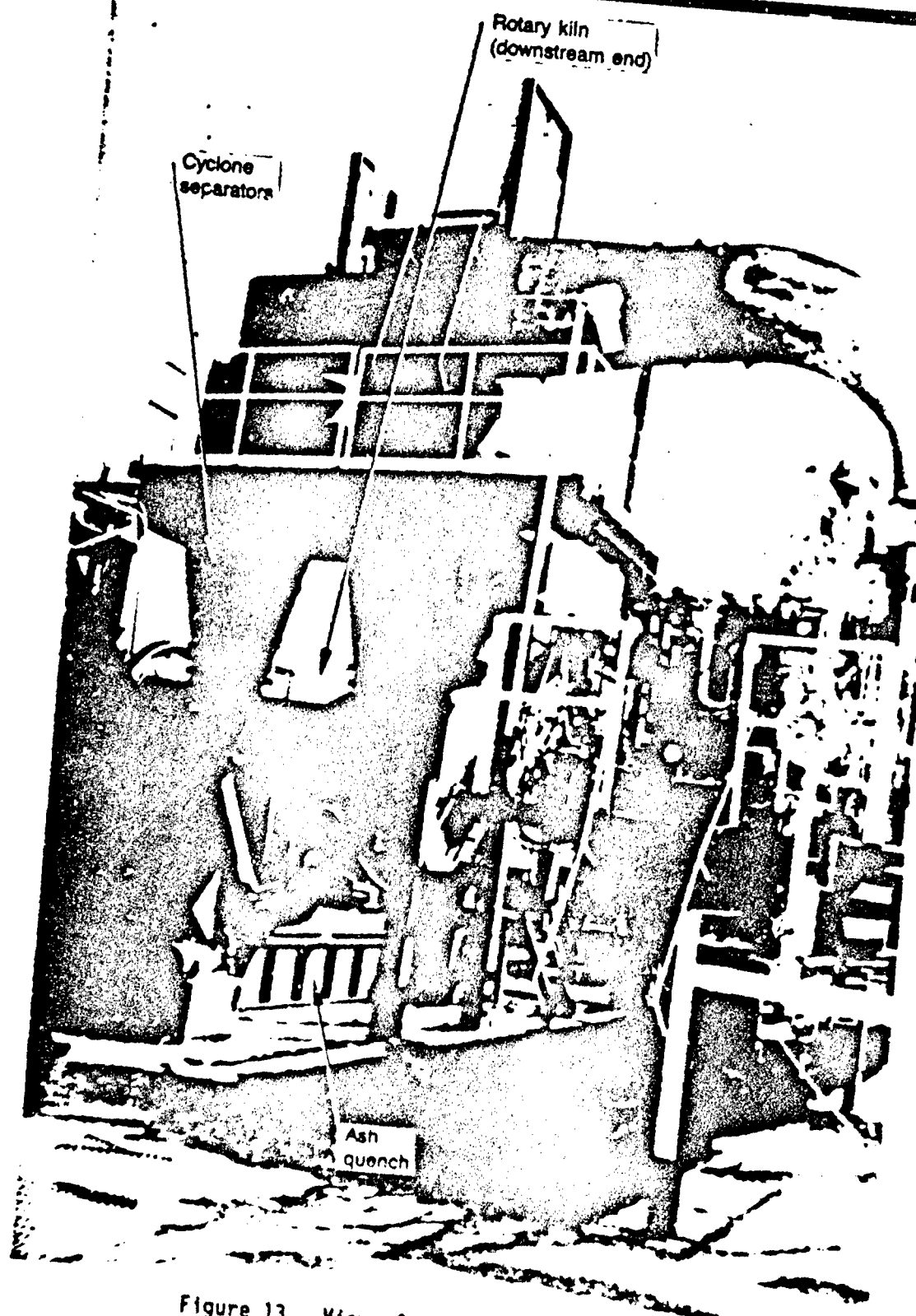
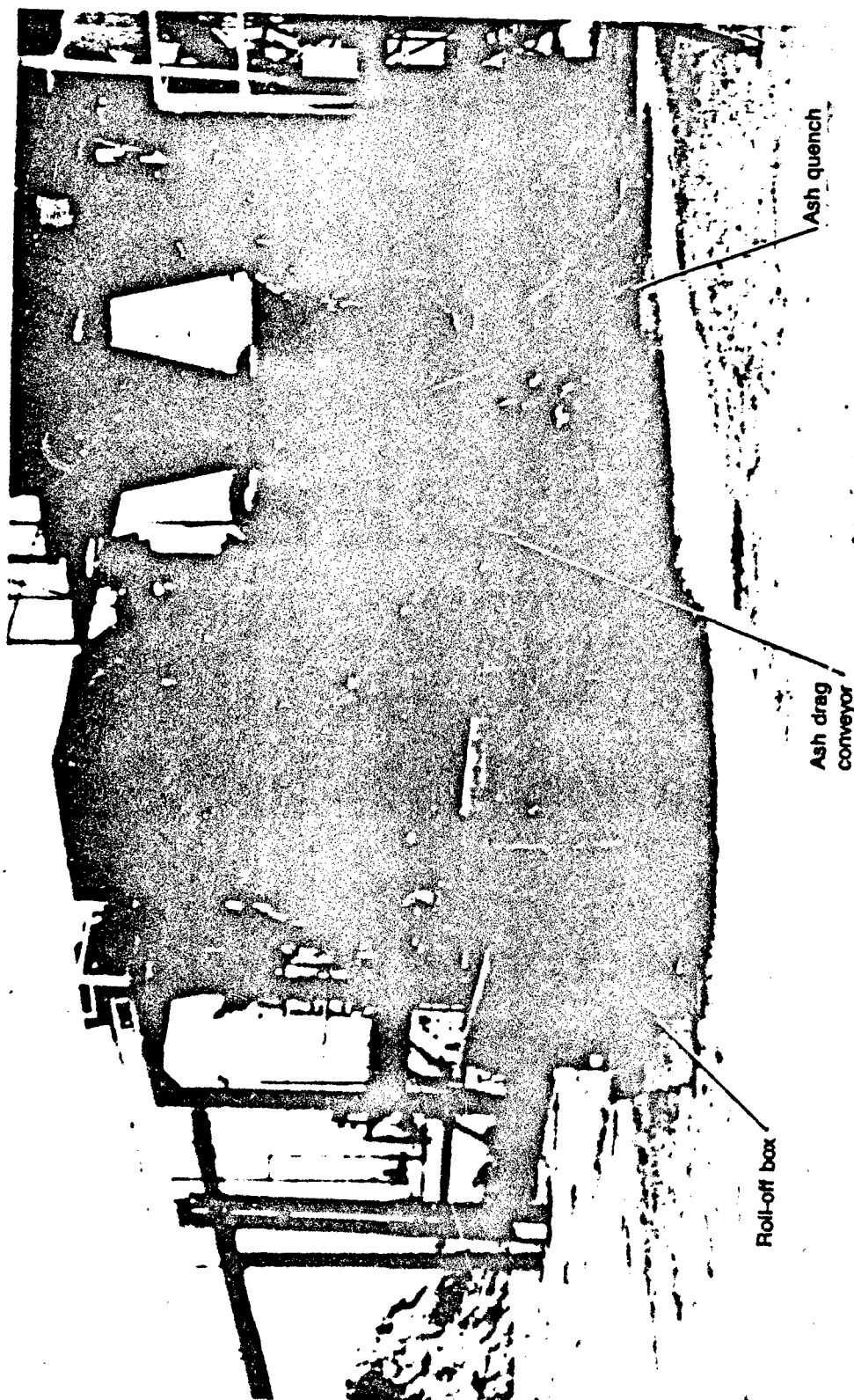


Figure 13. View of cyclones and ash quench.

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Figure 14. View of ash drag and rolloff box for ash collection.

removed particulate falls down into the ash quench. Although the incinerator has two cyclones in parallel flow paths, only one cyclone was used for this project.

5. Secondary Combustion Chamber (SCC)

The process gases leave the cyclone and flow into the SCC, which raises the temperature of the process gas to a minimum of 2150°F. This high temperature combusts any remaining organics in the off-gas. The SCC is shown in Figure 15. The SCC is approximately 40-feet long and sits on top of a flatbed tractor trailer.

The SCC is equipped with a vortex burner capable of producing approximately 24 million Btu/hour by burning natural gas. The burner can use fuel oil or propane, in addition to natural gas; however, those fuels were not used during the demonstration project. Similar to the kiln, the SCC can burn liquid organics or contaminated water by direct injection of the liquid into the burner flame. Liquid waste was not processed during the trial burn phase.

6. Gas and Liquid Effluent Waste Stream Control

Once the gases leave the SCC, they flow through a fire tube boiler designed to produce 250 psig steam by recovering heat from the off-gases. The waste heat boiler and its steam drum are shown in Figure 16. The steam produced in the boiler is used primarily for the ejector scrubber, which is discussed below.

In order to prevent molten and vaporous silica in the processed soil from glassifying onto the inside of the boiler tubes, water spray nozzles were installed between the SCC and the waste heat boiler. The injected water condenses the molten and vaporous silica so that the silica behaves as a particulate rather than as a gas and thus does not plate out onto the boiler tubes.

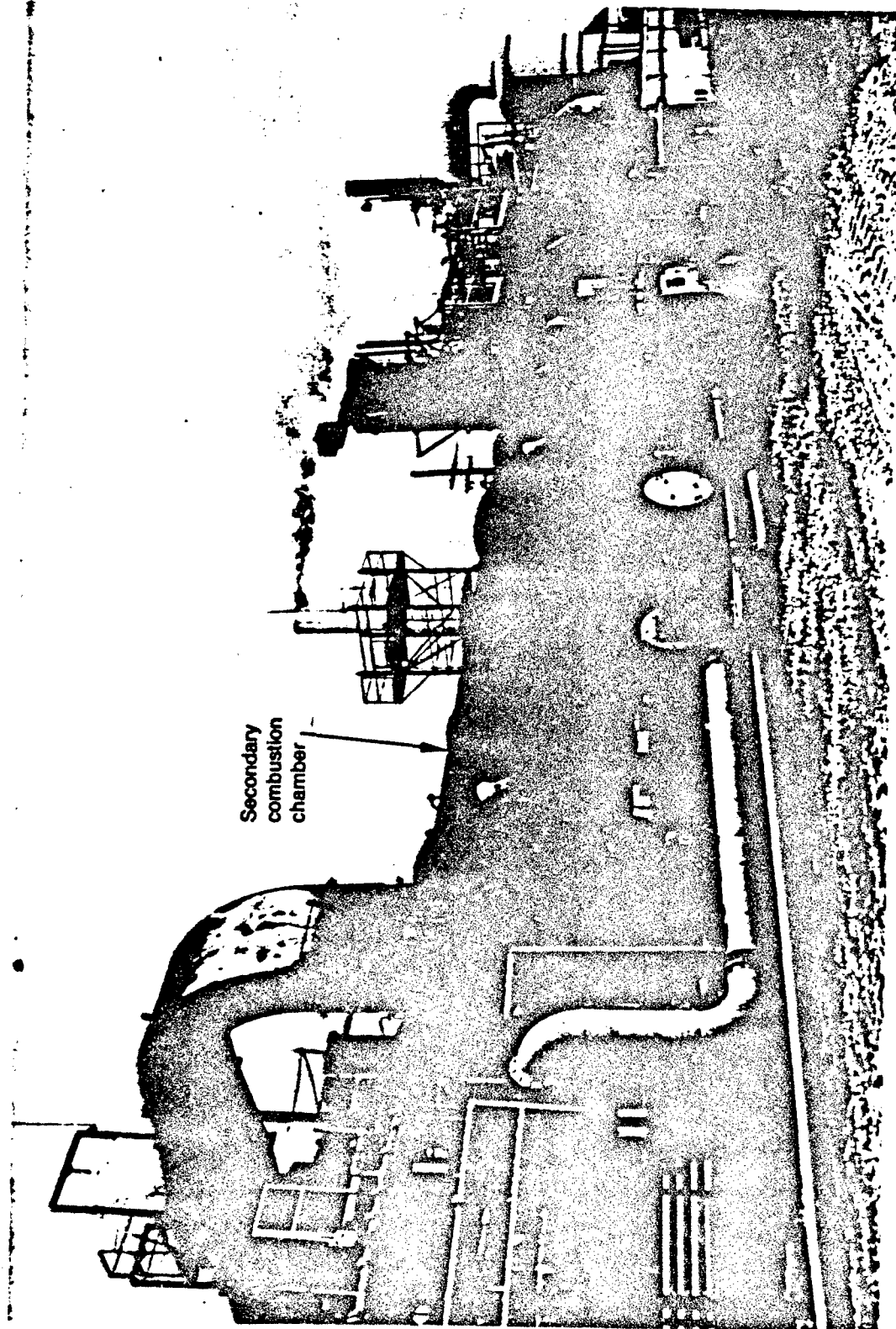
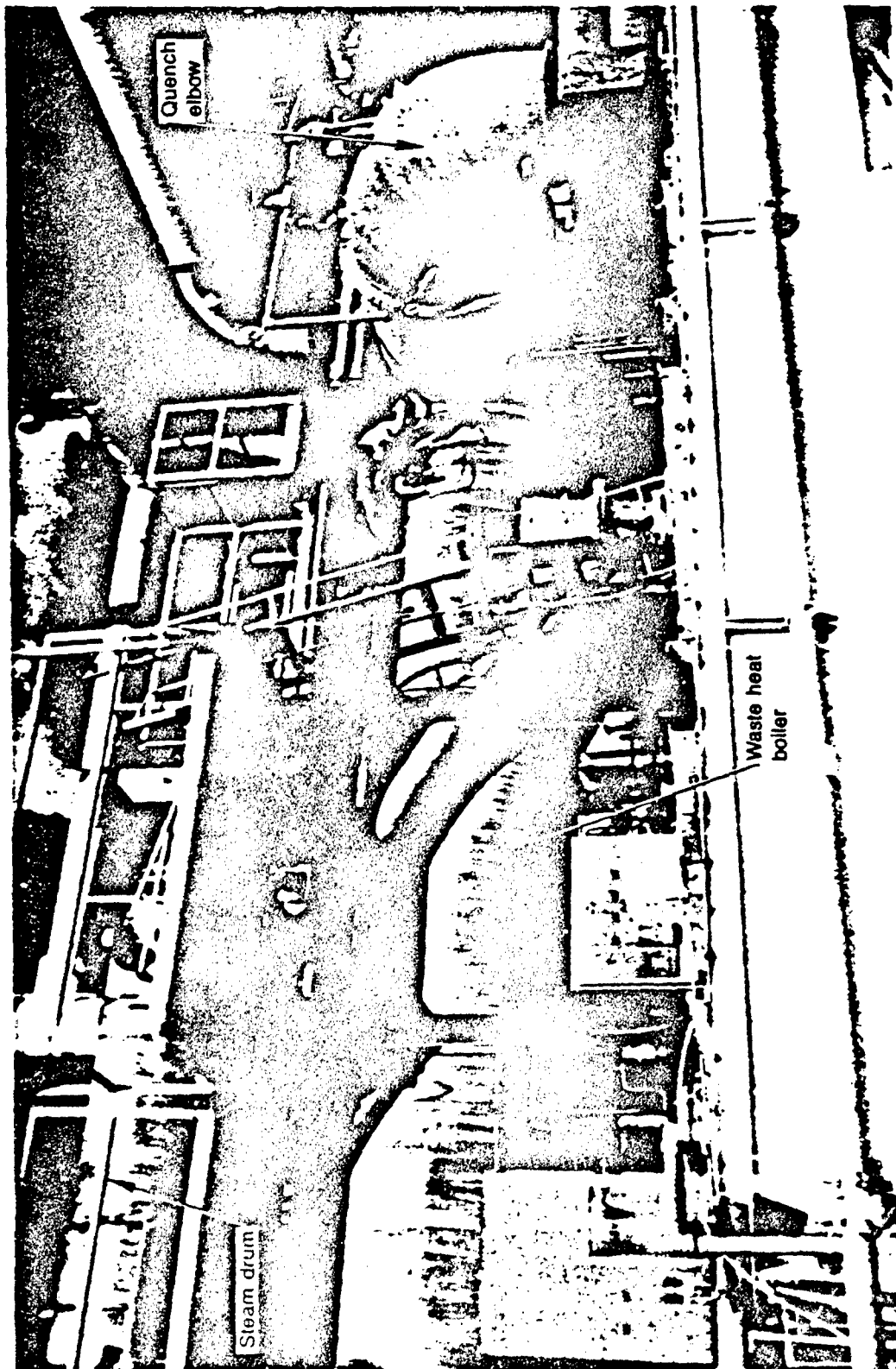


Figure 15. View of trailer-mounted secondary combustion chamber.

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Figure 16. View of waste boiler and steam drum.

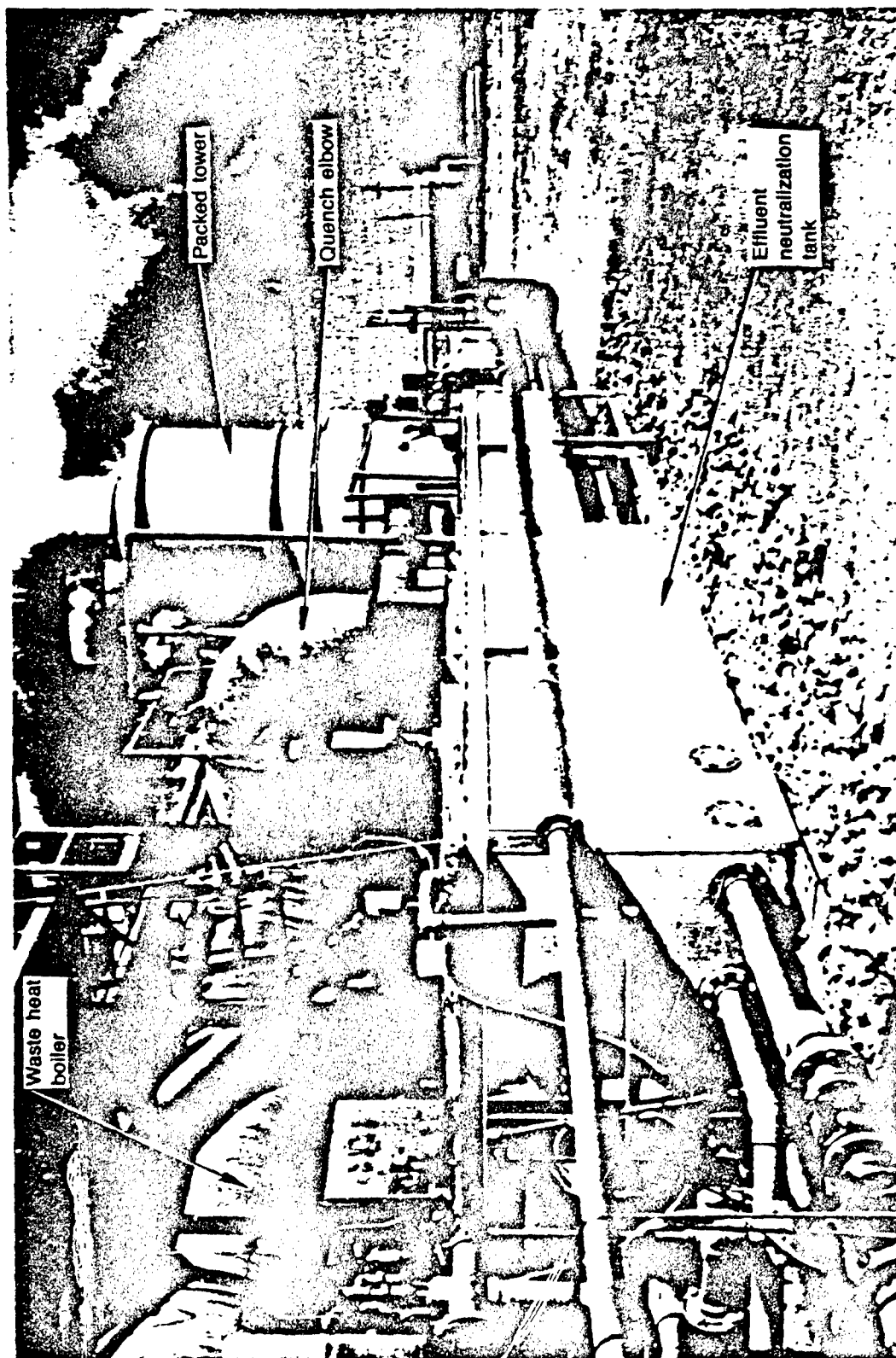
After the gases leave the boiler, they enter the quench elbow, the first among a series of devices that control effluent gas emissions. The quench elbow, shown to the right of the waste heat boiler in Figure 16, is designed to cool the off-gas by direct water injection. The injected water cools the gases to approximately 170°F, thus allowing the use of fiberglass-reinforced plastic for all downstream gas ductwork. Additionally, the quench elbow removes some of the acid gases.

The excess water from the quench elbow is collected in the effluent neutralization tank (ENT), which is in front of the quench elbow and packed tower shown in Figure 17. The ENT serves as the central collection point for all of the scrubber water used. The water collected in the ENT is used in a variety of scrubber applications. Caustic (e.g., NaOH) is occasionally added to increase the acid gas scrubbing efficiencies of the scrubbing water.

After the gases are cooled, they flow upward through the packed tower, which is a counter-current flow contact absorber (Figure 18). Water is sprayed in the tower at the top and flows downward over plastic packing material, which maximizes its contact with the upward-moving gases. The packed tower removes acid gases and particulate matter.

Upon leaving the packed tower, the gases flow into the ejector scrubber. The ejector scrubber, shown in Figure 19, serves two primary purposes: (a) to remove the fine particulate from the off-gases, and (b) to provide the motive force to draw the gases through the entire incinerator system. The ejector scrubber operates by injecting high-pressure steam into the annular region of the ejector scrubber. The steam acts as the motive fluid in an ejector pump and agglomerates the fine particles in the venturi section of the jet pump.

After leaving the ejector scrubber, the gases flow through a demister, also shown in Figure 19. The demister removes the condensate from the jet scrubber along with the agglomerated fine particulate captured in the condensate. The condensate water and particulate are pumped back to



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Figure 17. View of effluent neutralization tank with quench elbow and packed tower (background).

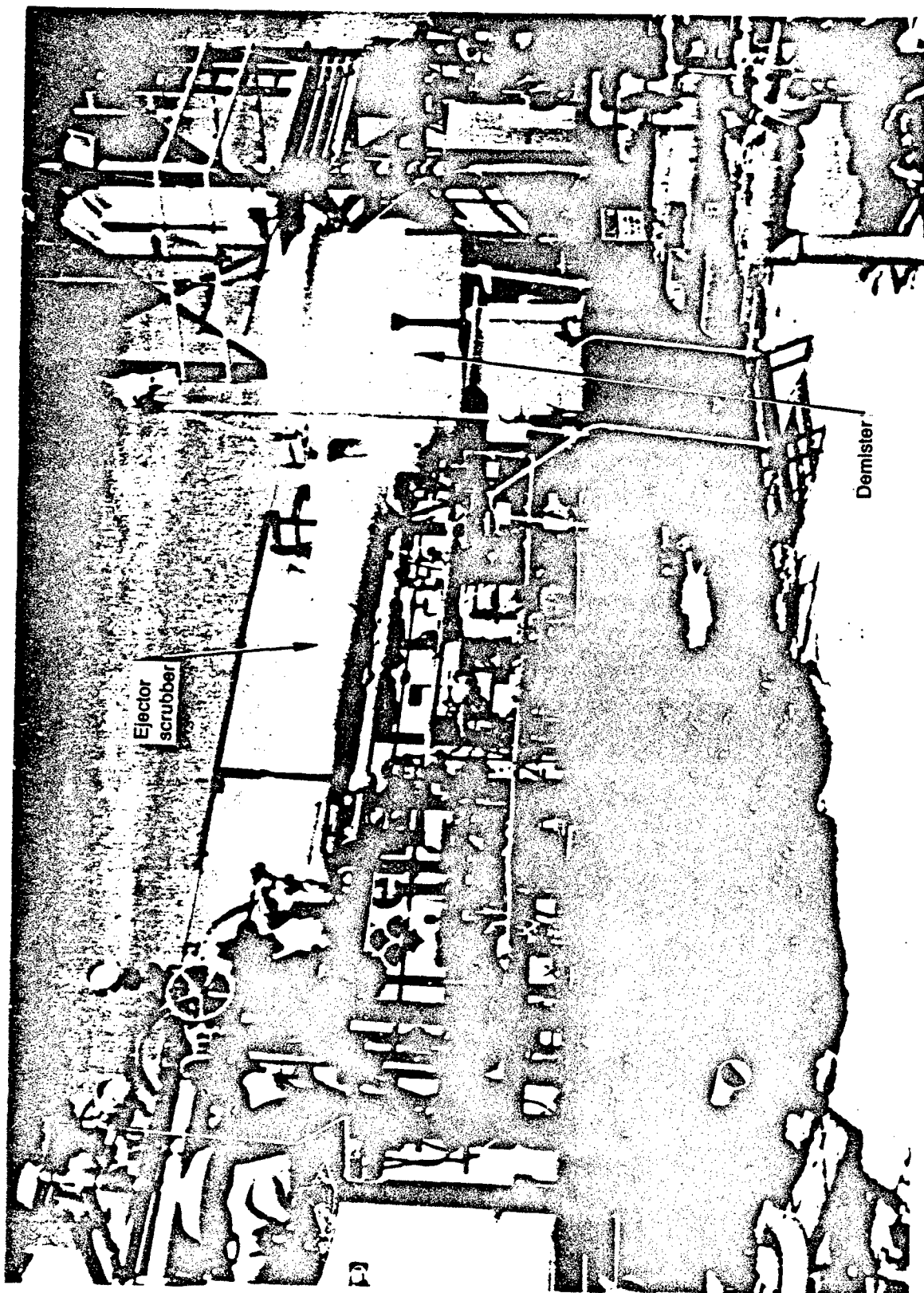


Figure 19. View of trailer-mounted ejector scrubber and demister.

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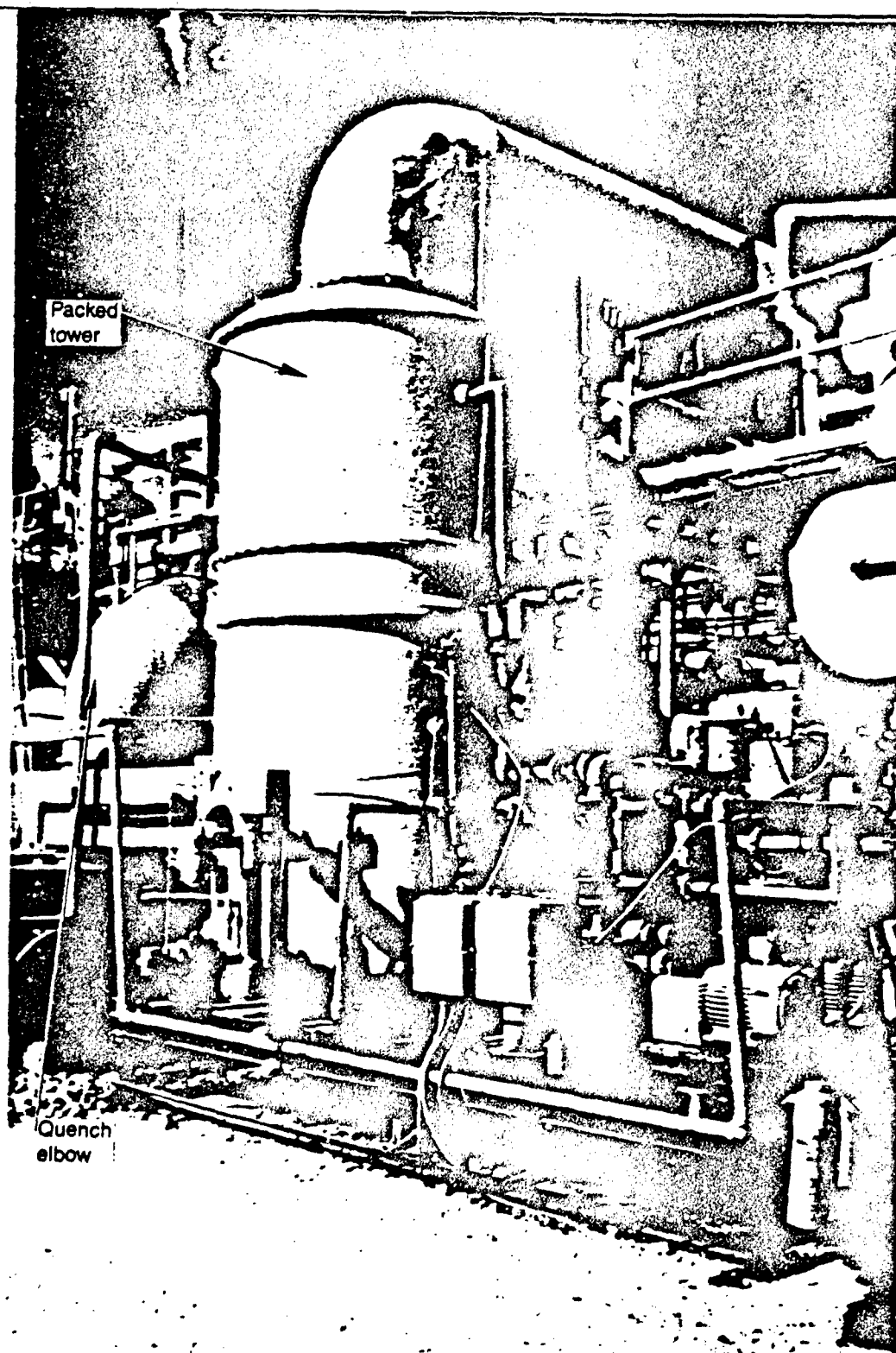


Figure 18. View of skid-mounted packed tower.

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the effluent neutralization tank for recycling. The combustion gases and steam from the jet pump are then exhausted through the 40-foot stack, as shown in Figure 20 (see also Figure 5). The ejector scrubber, demister, and stack are mounted on a flatbed tractor trailer; however, the stack is installed at the field site.

C. PROCESS MONITORING AND CONTROL

The incineration process is remotely monitored and controlled from an operator's panel located in a mobile control room trailer. This panel provides the operator with indications of process system parameters and those manual controls necessary to adjust system variables to required operating conditions. This includes numerical and status light indicators, switches, video monitors, and computer monitor (many of which are shown in Figure 21).

Monitoring by a personal computer-based data acquisition system (DAS) is central to the control process. The DAS collects data from electronic instruments that include a variety of thermocouples, pressure transducers, and level indicators. A complete list of the instruments is provided in Appendix A, Exhibit 3. In addition, the stack gas emissions are continuously monitored for carbon monoxide, carbon dioxide, and excess oxygen content. The combustion efficiency being achieved by the MWP-2000 incinerator system is continually calculated by the DAS from readings from the carbon monoxide and carbon dioxide monitors.

When active, the DAS can automatically stop waste feed if certain operational parameters fall outside the EPA permit specifications or if the flame to the kiln or SCC fails. Details of the automatic waste feed shutoff (AWFSO) system are provided in Appendix A, Exhibit 3.

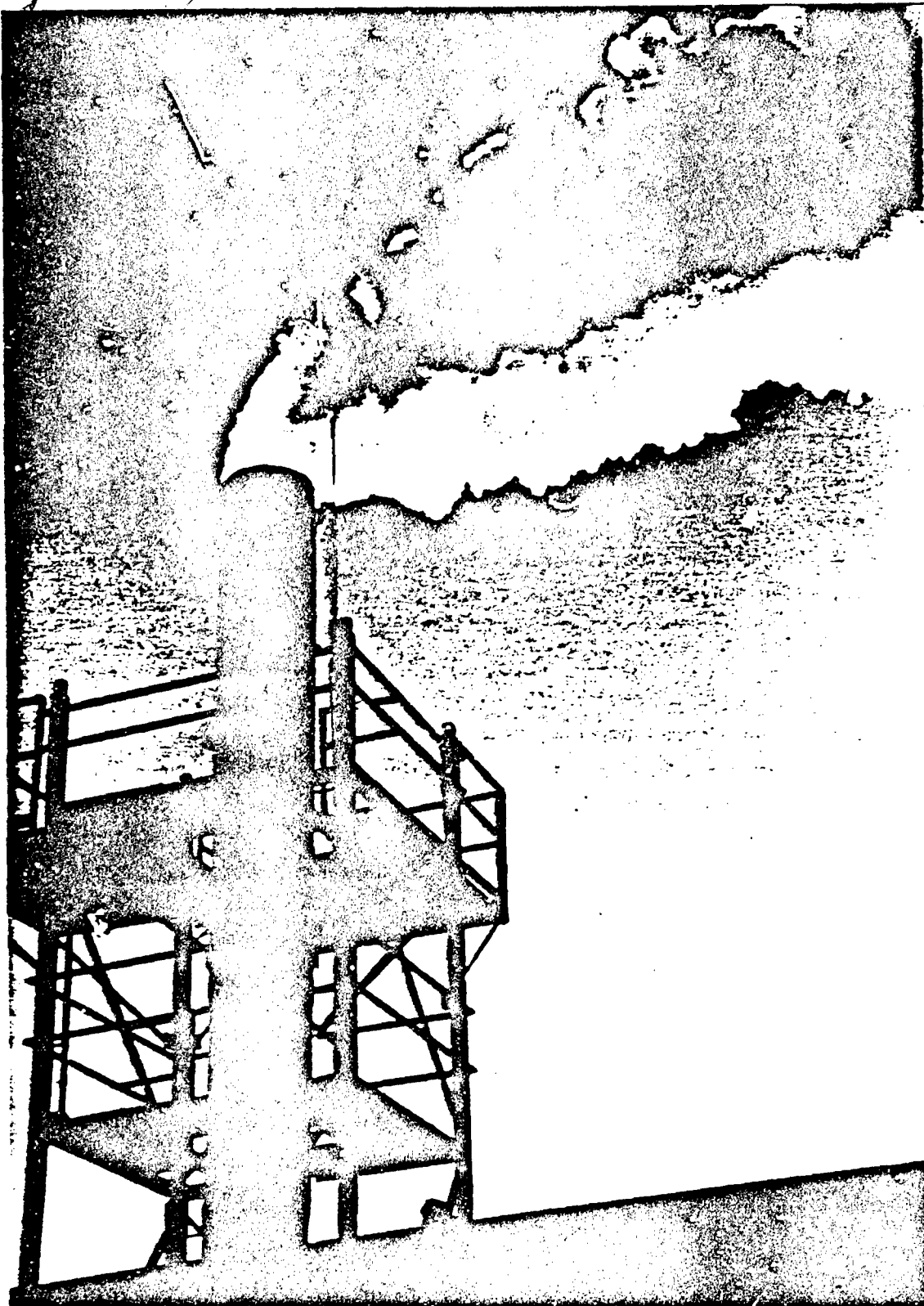


Figure 20. View of incinerator stack.

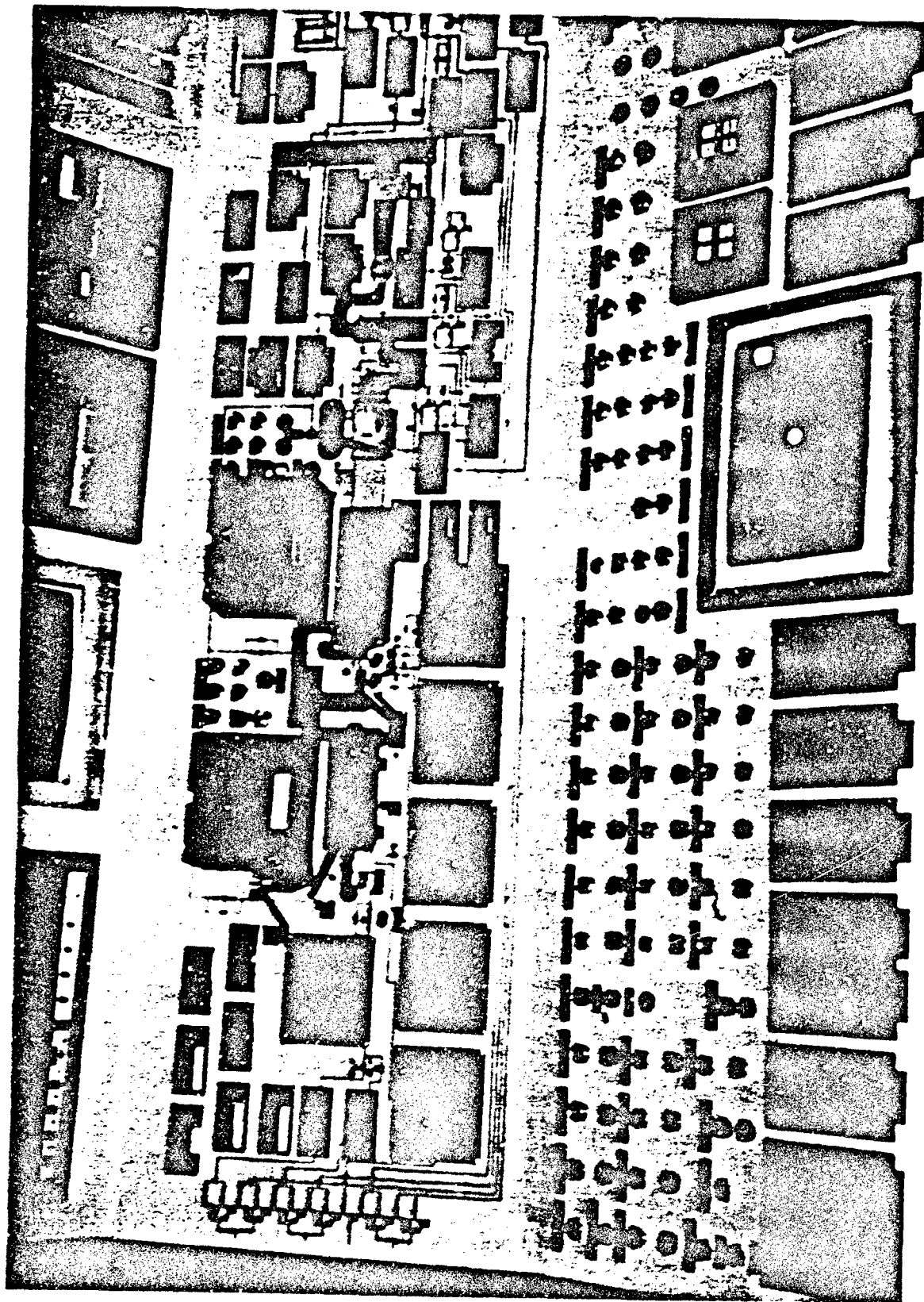


Figure 21. View of incinerator operator's control panel.

SECTION III

FIELD TEST METHODS AND APPROACH

A. TEST PLAN

Significant planning activities were completed to ensure safe and timely accomplishment of the trial burn test goals. These planning activities included:

1. Preparation of a test plan for the trial burn (Reference 21)
2. Revision to the existing spill prevention, control, and countermeasures plan.
3. Preparation of a quality assurance project plan (QAPP) (Appendix B).

EG&G Idaho, Versar, ENSCO and the Air Force jointly prepared the test plan. Versar prepared the QAPP and submitted it to EG&G Idaho for review. EG&G Idaho prepared the revision to the spill prevention, control, and countermeasures plan. All documents were submitted to the AFESC Project Representative for review before submittal to EPA Region IV for review before the trial burns. The health and safety plan and emergency and contingency plan from the verification test burns were reviewed and determined to be acceptable without need for revision for the trial burns; copies of these plans are shown as appendices in Reference 1.

The overall plan for the MWP-2000 incinerator system trial burn was to conduct the following activities over approximately a 25-day span: (a) start-up system, (b) conduct clean soil test, (c) blend surrogate in clean sand feedstock, (d) conduct two tests, each with three replicate performances, and (e) shut down the system. The first test was for nominal feed rate operation at 4 tons per hour. The second test was for nominal feed rate operation at 5 tons per hour. Approximately 300 tons of clean

commercial sand spiked with the HCE and 1,2,4-TCB was used. The amounts of HCE and TCB to be injected were planned to provide concentrations of each POHC in the range 1500 to 3000 parts per million (ppm). The objective of each test was to demonstrate greater than six nines DRE for the dioxin surrogates, as well as to satisfy the particulate and HCl emissions limits. Because the first test was operated at an average feed rate in excess of 5 tons per hour, the second test was cancelled.

Gas outlet temperatures for the rotary kiln and the SSC were planned at 1350 to 1800°F and 2150°F, respectively. Both units were fired on natural gas. Energy inputs for the kiln and SCC at nominal operating conditions were estimated at 14 MBtu/hour and 24 MBtu/hour, respectively. The planned approach was to reach operating conditions and operate with clean sand for three days of continuous operation and then follow with individual surrogate contaminated soil test runs. Periods of standby operation (no soil being fed) were phased between the initial clean sand checkout and the different tests to provide distinct identification for process sampling. Table 1 lists the planned operating conditions and parameters to be monitored during the trial burns. Ranges or operating setpoints are shown, with those parameters specified in the RD&D permit identified. Certain parameters are more restrictive than those specified in the original RD&D permit. EPA Region IV required that the operating conditions be at least as conservative as those observed during the verification test burns conducted in December 1986.

The waste feed for these tests was to be graded and washed material, such as sandblasting sand, mixed with the two surrogate compounds. Approximately 36 tons of clean sand was planned for the clean soil shakedown test and approximately 220 tons of surrogate spiked sand for the trial burn tests. Surrogate blending was planned to be batch mixed with the sand in a cement mixer (Reference 21). To meet desired concentrations, at least 200 pounds of each surrogate was estimated for each 9 cubic yard batch, and the surrogate would be added in four discrete equal positions and thoroughly mixed.

TABLE 1. PLANNED OPERATING CONDITIONS AND MONITORED PARAMETERS FOR
MWP-2000 INCINERATOR SYSTEM TRIAL BURN AT NCBC

<u>Parameter</u>	<u>Normal Range or Setpoint</u>
Nominal soil feed rate	Test 7: 4 ton/hr Test 8: 5 ton/hr ^{a,b}
Soil residence time	Variable 20-60 min
Kiln combustion air flow rate	120 lb/min
Kiln outlet gas temperature ^c	1350-1800°F
Kiln pressure ^c	negative pressure
Secondary combustor air flow rate	300 lb/min
Secondary combustor outlet gas temperature ^c	2100°F minimum
Secondary combustor pressure	negative
Gas residence time in secondary combustor ^c	1-2 seconds
Combustion efficiency	>99.0 percent
Boiler outlet gas temperature	450°F
Boiler steam pressure	220-240 psig
Boiler makeup water flow rate	20-30 gpm
Quench recirculation water flow rate	100 gpm
Quench makeup water flow rate	15 gpm
Quench outlet gas temperature	190°F
Packed tower recirculation water flow ^c	170 gpm ^d
Packed tower makeup water flow rate	15 gpm
Scrubber recirculation water flow rate ^c	40 gpm ^d
Stack gas oxygen ^c	3 percent minimum

TABLE 1. PLANNED OPERATING CONDITIONS AND MONITORED PARAMETERS FOR
MWP-2000 INCINERATOR SYSTEM TRIAL BURN AT NCBC (CONCLUDED)

<u>Parameter</u>	<u>Normal Range or Setpoint</u>
Stack gas CO ₂	Function of combustion efficiency
HCl emissions	1.8 kg/h or 1 percent of HCl concentration into the scrubber, whichever is greater
Particulate matter	180 mg/dscm corrected for O ₂

a. The trial burns conducted in May 1987 were to be designated as Tests 7 and 8 so as to not be confused with the verification test burns conducted in December 1986, designated as Tests 1-6.

b. Test 8 was later cancelled because the average feed rate of the three replicates for Test 7 exceeded 5 ton per hour.

c. Indicates parameter is a specified permit condition (permit shown as an appendix to Reference 1).

d. Approximate value, which may vary as necessary to achieve the required scrubber efficiency.

The POHC and sand mixture was mixed in a cement mixer with samples taken at hourly intervals. Analysis of the mixture showed that the POHC concentration was approximately one-fourth of the calculated concentration. This was true regardless of the mixing time.

An alternate method used POHC mixed with cotton seed hulls, which were in turn mixed with the sand in the cement mixer. It was quickly apparent that this method would also fail because the cotton seed hulls were visually observed to float to the top of the sand during mixing.

Finally, after these methods proved fruitless, EPA Region IV suggested that the POHC be placed in containers that could be dropped into the waste feed at discrete intervals. This method was previously suggested by the Air Force contractors but rejected by EPA. The alternate POHC injection method was formally submitted to and verbally accepted by EPA Region IV (Appendix A, Exhibit 6).

In the alternate method discrete quantities (1.5 pounds nominal) of the pure POHC were placed in polyethylene containers (sample bottle for 1,2,4-TCB; Ziploc baggie for HCE). The containers were then placed in the kiln feed hopper on a regular interval (every 3 minutes) throughout each test run. This alternative method of feeding the surrogate compounds to the process provided a higher degree of assurance that the POHC would enter the incinerator, while reducing the chance of inhalation or cross-contamination in the vicinity of the feed hopper. The POHC would be introduced into the kiln at least 45 minutes before the stack test was to begin, to ensure system equilibration with POHC. Detailed waste feed preparation and storage are discussed in Section IV.C.

Because the incinerator system had been previously exposed to HO-contaminants during the earlier verification test burns, the possible effects of cross-contamination were a concern. Planning called for the ENT, scrubber sump, packed tower and ash drag sump to be thoroughly rinsed before incinerator warmup. This rinse water was discharged to the PGW effluent storage tank via carbon bed filters. Samples were taken to ensure

concentrations of 2,3,7,8-TCDD, 2,4-D, and 2,4,5-T were nondetectable before discharge of the water in the sewer line. These results are discussed in Section IV.C.

Versar, Inc. of Springfield, Virginia obtained all onsite test samples and sent them to International Technologies Analytical Services (ITAS) in Knoxville, Tennessee, for analysis. This work, under contract to EG&G Idaho, served as verification of test results. ITAS is a certified participant in the EPA Contract Laboratory Program (CLP).

B. FIELD ORGANIZATION

ENSCO performed the incinerator operation and soil excavation activities. Those activities were supervised by an ENSCO project manager who was located onsite. Reporting to him were the operations supervisor and a health and safety representative. The MWP-2000 incinerator operations were organized into two shift crews of approximately 10 personnel each for round-the-clock operations.

Versar performed the onsite sampling with a crew of approximately 10 personnel. These activities were coordinated with ENSCO onsite supervision.

EG&G Idaho and AFESC project personnel provided the technical monitoring in the field. During field tests, this monitoring served to observe, direct (but not supervise) subcontractor personnel, and to ensure procedural compliance by the demonstration and sampling effort. AFESC project representatives were also onsite during the demonstration to provide liaison among the Air Force, the Navy, and the EPA, as necessary.

C. DETAILED RATIONALE FOR SURROGATE SELECTION

1. Detailed POHC Selection Rationale

A POHC is the most prevalent or most difficult hazardous organic compound found in a waste to be incinerated. Success of a dioxin/furan

trial burn depends upon demonstrating 99.9999 percent DRE on the POHCs selected. During the preparation of a trial burn, the EPA will evaluate the proposed waste stream and all of its hazardous constituents. Based upon that analysis, 40 CFR 270.62 states that the EPA administrator will specify one or more POHCs, based on his estimate of the difficulty of incineration of the constituents identified in the waste analysis, their concentration, or their mass in the waste feed.

In practicality, however, the owner or operator of the incinerator will make a request in the trial burn plan to use the POHCs that best suit the needs of his particular incinerator and waste stream. The EPA administrator will then approve or disapprove those POHCs or suggest an alternative POHC.

Normally, the trial burn POHC is one of the hazardous waste components inherent in the waste stream. At least two POHCs are normally chosen; one POHC is the hazardous component in greatest abundance while the second is the component that is most difficult to incinerate. For example, the POHC for NCBC would normally be 2,3,7,8-TCDD, and the herbicides 2,4-D or 2,4,5-T; 2,3,7,8-TCDD is difficult to incinerate and the herbicides are in great abundance. However, the concentrations of those compounds in the NCBC soil were too low to perform a successful trial burn (see Section I.B.4). Additionally, EPA Region IV staff emphatically refused a request to process the dioxin-contaminated native soil under any circumstances during the trial burn or an incinerator shakedown period pursuant to 40 CFR 270.62(a), which allows up to 720 hours of shakedown testing. EPA was apparently concerned about processing dioxin-contaminated waste in an incinerator that had not yet been demonstrated to meet the required 99.9999 percent DRE.

Therefore, instead of using native POHCs for the NCBC trial burn, a surrogate POHC and soil matrix were chosen to simulate the contaminated native NCBC soil. The surrogate POHCs were 1,2,4-trichlorobenzene (TCB) and hexachloroethene (HCE). Clean builders sand was chosen as the surrogate

soil matrix. A variety of competing factors are involved in selecting those surrogates. This section describes the method and rationale used to select the surrogates.

Table 2 presents the data discussed below for the two POHCs chosen as well as other compounds of interest.

a. Need for Two Distinctive POHCs

In theory, if one chooses the hazardous constituent most difficult to incinerate as his POHC and demonstrates a successful trial burn, any other Appendix VIII constituent that is easier to incinerate may be burned during normal operations. However, the methods used to determine a POHC's incinerability are approximate; therefore EPA permit writers normally prefer to determine DRE compliance based upon at least two POHCs (Reference 22).

Additionally, the choice to use at least two POHCs has definite advantages and could provide significant cost savings. Demonstrating successful 99.9999 percent DRE on two distinct compounds may remove certain regulatory doubts concerning the ability of the incinerator to protect the environment. If the trial burn results were successful on one POHC, yet inconclusive on the other, one could then argue that the test was a success and be granted an operating permit, thus saving the expense of repeating a trial burn.

Using two POHCs is not without risk, however. For example, if the trial burn results conclusively show less than 99.9999 percent DRE for one POHC, then it would be doubtful whether the incinerator could process the other POHC, or protect the environment during normal operations; thus, permission to operate could be denied. However, if the POHC is chosen correctly and a well-defined trial burn plan is followed, successful incineration of one POHC should ensure success of the other POHC.

TABLE 2. SUMMARY OF THERMAL PROPERTIES OF VARIOUS POHCS

COMPOUND	HEAT OF COMBUSTION (Kcal/gram)	T-99.99/2 Degrees C	PHASE @ 70 DEG F	BOILING POINT	MELTING POINT
1,2,4-Trichlorobenzene	3.40 (4)	790 (a)	Liquid	213 (b)	17 (c)
Hexachlorobenzene	1.79 (4)	880 (a)	Solid	323-326 (c)	229 (c)
2,3,7,8-tetrachlorodibenzo-p-dioxin	3.43 (4)	--	Solid	--	
2,4,5-trichlorophenoxyacetic acid	2.87 (4)	--	Solid	--	153 (b)
2,4-dichlorophenoxyacetic acid	3.62 (4)	--	Solid	160 (b)	138 (b)
Hexachloroethane	0.46 (4)	640 (a)	Solid	186.8 sublimes (c)	186.8 sublimes (c)
Tetrachloroethylene	1.19 (4)	920 (a)	Liquid	121	-22.4

a. Dellinger et al., Determination of the Thermal Decomposition Properties of 20 Selected Hazardous Organic Compounds, University of Dayton Research Institute, Dayton, Ohio.

b. The Merck Index, 8th Edition, Merck & Co., Rahway, New Jersey, 1968/RJ.

c. Mitre Corp., "Guidance Manual for Hazardous Waste Incinerator Permits," prepared for Environmental Protection Agency, Washington, D.C., Office of Solid Waste and Emergency Response, National Technical Information Service, PB84-100577.

At the suggestion of EPA Region IV staff, during meetings held in early March 1987, a decision was made to use two POHCs for the NCBC trial burn.

b. Incinerability

According to the EPA regulations, the POHC chosen for the trial burn must be the POHC that is most difficult to incinerate in the anticipated waste stream, or a surrogate POHC that is more difficult to incinerate than the waste that will be processed during normal operations. Currently, EPA uses the heat of combustion as the ranking system (Reference 22). The lower the heat of combustion, the more difficult the compound is to destroy. Therefore, the POHC chosen for the NCBC trial burn was required to have a lower heat of combustion than the three native POHCs of 2,4-D, 2,4,5-T, and 2,3,7,8-TCDD. Table 2 lists the heats of combustion for the native NCBC POHCs, in addition to several other POHCs considered for the trial burn.

For several years, EPA has sponsored extensive research toward developing an alternative POHC ranking system. During meetings with EPA in early March 1987, EPA Region IV staff suggested that the thermal decomposition ranking system proposed by Dellinger (Reference 23) would be more appropriate than the heat-of-combustion ranking system. To accommodate the EPA's research desires and the practical need to quickly demonstrate RCRA six nines compliance, project personnel made an attempt to select a highly refractory POHC based upon both the thermal decomposition system and the heat-of-combustion system.

The thermal decomposition unit-gas chromatograph (TDU-GC) was developed by Hall and Dellenger (Reference 23). In that system, known quantities of POHC were introduced to a heated vessel and thermally decomposed during a precisely measured retention time. The products of combustion, including any noncombusted POHC, were swept into a high-resolution gas chromatograph and analyzed. Thermal decomposition profiles were developed for a variety of POHCs at a variety of retention

times and reactor temperatures. From those data, various POHCs were ranked according to which temperature provides 99.99 percent destruction. That temperature is named T-99.99. Presumably, the higher the T-99.99, the more difficult the compound is to destroy. T-99.99 temperatures in the 840 to 940°C range indicate a very stable compound. Table 2 lists the temperatures at which 99.99 percent destruction was observed for several POHCs that were considered for the NCBC trial burn.

At the time of the NCBC trial burn, the native NCBC POHCs had not been tested. However, conversations between EPA Region IV staff and Dr. Dellenger indicated that, based upon unpublished data, hexachlorobenzene (HCB) would be a highly refractory material suitable as a surrogate POHC in lieu of 2,3,7,8-TCDD. HCB was therefore deemed to be a prudent choice because it is considered very difficult to incinerate, based upon both the heat-of-combustion ranking system and the TDU-GC system. The draft trial burn plan specified HCB as one of the POHCs. Unfortunately, as described below, HCB was unavailable; therefore, an alternate POHC was specified in the final trial burn plan.

The search for an alternative surrogate POHC with the necessary incinerability characteristics was not a trivial task. Although the T-99.99 ranking system had distinct advantages, ultimately it was not used as an incinerability ranking system because sufficient peer-reviewed data did not exist that could relate the surrogate POHC to the native POHCs. Additionally, many other RCRA trial burns, which used the EPA-accepted heat-of-combustion ranking system, had been successfully conducted. Therefore, project personnel decided to use the heat of combustion as the primary incinerability ranking system while still retaining the T-99.99 values as a general incinerability guideline.

Based upon the heat of combustion, tetrachloroethylene and 1,2,4-trichlorobenzene appeared to be prudent second choices. Furthermore, based upon the T-99.99 values, tetrachloroethylene is the more refractory material; therefore, one would logically conclude that it would be the POHC of choice. However, the other POHC, hexachloroethene, was chosen based

upon its extremely low heat of combustion; a second POHC with a very low heat of combustion was not necessary. Indeed, the use of a second surrogate POHC more refractory than the native POHC could be detrimental to the success of the trial burn. For example, if 99.9999 percent DRE was not demonstrated for both surrogate POHCs, then the EPA would almost certainly deny permission to commence operation. If, however, a POHC that possessed very similar incinerability characteristics was successfully treated during the trial burn, one could argue for permission to commence operations, regardless of the outcome of the substantially more refractory surrogate POHC.

Therefore, 1,2,4-trichlorobenzene was chosen because its heat of combustion was nearly identical to that of 2,3,7,8-TCDD and because its T-99.99 value indicated that it was a moderately refractory material. Additionally, 1,2,4-TCB had been successfully used to demonstrate a DRE greater than 9.9996 percent at the EPA Combustion Research Facility (Reference 24).

Hexachloroethylene was chosen as the second POHC because of its very low heat of combustion. It was felt that this compound could demonstrate the fringes of the MWP-2000 incinerability operating envelope, i.e., it could act as a worst-case POHC.

c. Vapor Pressure

Vapor pressure is perhaps the second most important property to consider when selecting a POHC. Volatile compounds, i.e., compounds with a relatively high vapor pressure, generally have boiling points below 130°C. Semivolatile compounds generally have lower vapor pressures with boiling points greater than 130°C. Semivolatile compounds are desired because a Modified Method 5 (MM5) sample train with an XAD^R or Tenax^R resin module can be used. If a volatile compound is chosen, then sampling requires a Volatile Organic Sampling Train (VOST), which is a rather fragile and difficult piece of equipment to operate. The required sampling method for a particular POHC is specified in SW-846 (Reference 19).

Vapor pressure is also a prime consideration when determining the method of feeding the POHC to the incinerator. Difficulties can easily arise when trying to measure the quantity of a volatile POHC added to the incinerator. If the quantity of a volatile POHC is not completely contained and measured immediately before injection into the incinerator, the compound may volatilize between the time that it was weighed and the time it actually entered the incinerator. This difficulty imposes a high bias in the DRE calculation. To avoid this problem, a compound with a low vapor pressure is desired.

Low vapor pressure compounds also present a significantly lower health safety risk factor. Because large quantities of POHC are typically needed, a low vapor pressure compound reduces the potential for airborne exposure to nearby workers. When considering worker exposure, however, the overall chemical's hazard must be considered, not just the vapor pressure.

The two POHCs chosen, HCE and TCB, are both semivolatile compounds; their boiling points are listed in Table 2.

d. Analytical Methods

During a trial burn, a stack gas sample is passed through a collecting medium that is specific to the POHC. Therefore, selection of both the POHC and the collecting medium must be complementary. Semivolatile POHCs may be collected on XAD^R, Tenax^R, or Florisil^R resins. Florisil^R resin, however, is very sensitive to the sample's water content; because of the extremely high water content in the stack gas, Florisil^R was not considered for the NCBC trial burn.

Test planners are cautioned to consult SW-846 (Reference 19) to ensure compatibility between the POHC and the resin. Ideally, one resin should be compatible for both POHCs. Only one resin module can be used per sample train, thus POHC/resin compatibility avoids having to obtain separate simultaneous gas samples.

After the gas sample is collected on the resin, it must be extracted from the resin. This is done using a solvent. The solvent extractant is then analyzed in a gas chromatograph/mass spectrometer (GC/MS). The two POHCs should be chosen such that their GC/MS mass-to-charge ratio (m/z) peaks provide a unique signature and thus are identified from each other. If the peaks are in the same range, then quantification of the compound in the sample could be unreliable. This is especially true if extremely low detection limits are needed.

The mass-to-charge ratio for HCE peaks at 210 with secondary peaks at 199 and 203. The mass-to-charge ratio for TCB peaks at 180 with secondary peaks at 182 and 184. These two peaks are far enough apart on the spectrum to not cause any cross-interference, yet close enough to simplify instrumentation.

e. Formation of PICs

Certain compounds, when incinerated, are not completely destroyed and thus form partially incomplete combustion products (PICs). When analyzed in the GC/MS, the PICs formed may have peaks similar to the original POHC. Additionally, the POHCs may be identical to some of the PICs formed. For example, carbon tetrachloride is a commonly formed PIC that has been used in other trial burns because of its refractory qualities. If combustion of the second POHC formed carbon tetrachloride as a PIC, then the DRE calculation could have a low bias.

The possibility of forming other hazardous PICs must also be considered. For example, Acetonitrile and Acrylonitrile were specifically rejected as POHCs because they can potentially form cyanide gas as a PIC.

At the time of POHC selection, there were no data to indicate that TCB, HCB, or HCE formed PICs that would potentially cause the aforementioned difficulties.

f. Phase

Because only solid waste would be processed during normal operation, the NCBC trial burn used clean builders sand as a simulated waste stream. The POHC had to be mixed or introduced into the sand before incineration. Various techniques (as discussed in Section III.3) were used in an attempt to batch mix the POHC with the builders sand. Those attempts failed. Therefore the POHC was introduced directly into the incinerator's feed hopper in discrete quantities on a regular, periodic basis.

The draft trial burn plan specified HCB and HCE, which are both white, granular crystalline or needle-shaped solids. As mentioned previously, HCB was unavailable and 1,2,4-TCB, an oily amber-colored liquid, was chosen instead. In hindsight, it would have been easier, from a material handling standpoint, to have both POHCs of the same phase as originally intended. If both POHCs were the same phase, only one set of procedures for material handling, weighing, and packaging would have been required.

For the NCBC trial burn, two solid-phase POHCs would be desired because bulk solids are easier to handle using forklifts and require fewer spill prevention precautions.

g. Availability

Regardless of which POHC is chosen, its use is ultimately determined by availability. For example, both EPA Region IV and the project's technical staff wanted to use hexachlorobenzene. Unfortunately, because of its inherent hazards and stringent regulations regarding its manufacture, storage, and use, there were no domestic bulk sources for the compound. One source was found in Great Britain; however the delivery time, transportation, import customs, and extraordinary cost all made the usage of hexachlorobenzene infeasible.

TCB and HCE were both readily available from a variety of sources at reasonable costs. The TCB was obtained from a distributor in Utah at a cost of \$3.50 per pound, and the HCE was obtained from a distributor in Cleveland, Ohio at a cost of \$0.75 per pound. Eleven hundred pounds of TCB and 4,015 pounds of HCE were ordered and delivered. (The unused HCE was surplus at the end of the project.)

h. Disposal of Treated Surrogate Waste

When selecting a POHC, it is prudent to select a compound that meets the above technical needs and is not listed or defined as a hazardous waste by 40 CFR 261 et seq. If the treatment residue could be considered a hazardous waste, then the trial burn residue must be disposed in an approved manner or delisted. Both of those options are costly. Such was the case for the NCBC trial burn residue. Because HCE is listed as a U131 waste, the treatment residue was determined to be a hazardous waste, although analysis showed the HCE concentration to be less than 330 ppb (detection limit). The treatment residue was sent to an approved landfill.

2. Surrogate Soil Selection

Although EPA Region IV denied permission to use native NCBC soil, that denial ultimately became technically and logistically advantageous. The native NCBC soil is a sandy matrix that was mixed with Portland cement as a stabilizer. When the soil is excavated, the large chunks of cement must be crushed or shredded. At the time of the trial burn, large rock-crushing equipment was not readily available, and the existing shredder located below the weigh hopper had not been reliably demonstrated.

Additionally, the potential presence of other organics from road tar in the native soil had not been confirmed or denied. It was felt that those potentially existing organics could contribute to analytical interferences in the POHC analysis.

Therefore, project personnel decided to use a surrogate soil matrix to avoid potential mechanical and analytical problems associated with native soil. Previous trial burns performed by ENSCO on another MWP-2000 incinerator had used clean builders sand as a surrogate soil matrix. Those tests indicated that no significant solid feed problems were encountered; therefore, that experience was employed for the NCBC trial burn.

Several local suppliers of builders sand were located in Southern Mississippi. Approximately 300 tons of sand were transported to the site and stored in large tents for rain protection.

D. HEALTH AND SAFETY

1. Personnel

ENSCO prepared a Health and Safety Plan for operating the MWP-2000 incinerator system with HO-contaminated soil before the NCBC verification test burns (included as an appendix to Reference 1). This plan was derived from standard health and safety procedures developed and used routinely by ENSCO personnel during operation of earlier units. It included unique aspects of the MWP-2000 and NCBC site. Specific contaminants addressed were 2,3,7,8-TCDD, 2,4-D, and 2,4,5-T. The plan was approved by certified industrial hygienists at ENSCO and concurred by EG&G Idaho. It met EPA Region IV approval through the permit process.

a. Contaminant Exposure

A formal change to the Health and Safety Plan was not done for the trial burn; however, the planned operation with the pure surrogate compounds was reviewed for a change in protective clothing and equipment requirements for operating personnel. Permissible exposure limits (8-hour time-weighted average) for 1,2,4-TCB and HCE were 40 and 100 mg/m³, respectively (Reference 25). The industrial hygienist's recommendations are summarized below.

Personnel handling the pure 1,2,4-TCB and HCE surrogate compounds during the feed stock preparation would be in Level A protective clothing and respiratory equipment, consisting of the following:

- Disposable encapsulated suit
- Self-contained breathing apparatus (SCBA)
- Protective gloves
- Protective outer boots
- Cotton coveralls
- Steel toed boots
- Hard hats.

The positive pressure operating SCBA has a protective factor of 10,000 and is classified for use in atmospheres having unknown concentrations of contaminants (Reference 26). Field monitoring with a direct reading instrument would be used to determine actual exposure levels and to generate data for evaluating the Level A protection requirement. These results are discussed in Section IV.C.4.

Level C respiratory protection and protective clothing requirements listed below were prescribed for all other personnel within the contaminated zone:

- Hood and boot Tyvek^R disposable coveralls
- Cotton coveralls
- Full-face, powered air-purifying respirator (PAPR)

- Hard hat
- Steel-toe and shank work boots
- Boot covers
- Protective gloves.

The PAPR, equipped with organic vapor and high-efficiency particulate arresting (HEPA) filtration cartridges, has a protection factor of 2,000 (Reference 26). Regular air dust monitoring with a digital dust indicator was planned for checking results from analysis of the filter cassettes. Upon receipt of the dust cassette results from the initial trial burn test and comparison with the digital dust indicator results, possible reduction of protection of Level C, plus half face air-purifying respirator (APR), would be determined. An APR has a protection factor of 10 to 100, depending upon fit (Reference 26). Previous experience from the verification test burns suggested that reduction of protection (except for the surrogate compound handlers) would be likely. Also, the change in surrogate sand mixing eliminated handling of contaminated soil. Field monitoring, discussed in Section IV.C.4, was performed to confirm that these requirements were adequate.

b. Heat

Because the process involved release of considerable heat and because the Mississippi climate becomes quite hot in May, the required respiratory protection and protective clothing could have caused personnel heat stress, which was a serious concern. Therefore, heat stress of employees on the site was monitored by the Wet Bulb Globe Temperature Index (WBGT) technique, which uses a heat stress monitoring device such as the Wibget[®] Heat Stress Monitor manufactured by Reuter Stokes. The WBGT is compared to the threshold limit value (TLV) outlined in Reference 25. Control measures to help reduce personnel heat stress were listed in the Health and Safety Plan (appendix in Reference 1).

2. Soil

Application of dust suppressants was planned to control fugitive dust emissions, especially during sand handling. The clean sand was stockpiled in a tent near the weigh hopper (see Section IV.B.1). A front-end loader transferred the soil to the weigh hopper.

The incinerator ash drag dropped the treated soil into 20-yd³ rolloff boxes. A translift truck picked up the boxes and transferred the treated soil to a lined storage area onsite.

3. Equipment

Numerous safety interlocks for the MWP-2000 incinerator system are discussed in an appendix to Reference 1. In addition, standard operating procedures were available from the verification test burns for the operators to follow during normal and abnormal operations.

A number of system failures were addressed in the emergency and contingency plan prepared for the verification test burns and included as an appendix to Reference 1. Fire and explosion were two such events. The risk due to fire was found acceptable based on the following:

- National Fire Protection Association and Factory Mutual approvals of shutoff devices for the incinerator's natural gas system
- Fire Department inspection of the installation
- Fire Department located only three blocks away
- A number of fire extinguishers (e.g., chemical powder, Halon, CO₂) were placed according to identified needs.

A postulated explosion of the incinerator system, with subsequent internal 1,2,4-TCB/HCE contamination to the workers at the incinerator site, was considered to be the worst-case accident during the trial burn, as bounded by the earlier assessment assuming 2,3,7,8-TCDD. Those workers who were not wearing respirators, if uninjured from the postulated explosion, could quickly don their assigned respirators and evacuate the immediate area, thus minimizing their risk. The injuries sustained to a worker as a result of a postulated explosion would be obviously much more significant than any potential injuries sustained as a result of 1,2,4-TCB/HCE contamination. Workers standing at the former-HO storage site boundary during such an accident could conceivably be exposed to 1,2,4-TCB/HCE during worst-case weather conditions. If an explosion were to occur, NCBC emergency response requirements would immediately be activated for notification and evacuation.

4. Spill Prevention and Control

The spill prevention, control, and countermeasures plan (Appendix D) was revised for the trial burn to include the use of the two surrogate organic components, 1,2,4-TCB and HCE. The following hazardous substances could be spilled during the MWP-2000 incinerator system trial burn, as identified in the plan:

- Stored quantities of 1,2,4-TCB and HCE at the site
- Small quantities of mercury (used in instrument calibration)
- ENT contents (could contain 1,2,4-TCB and/or HCE if the incinerator was operated out of its operating limits)
- Fuel (diesel)
- Acids and caustics (used for boiler water treatment).

HCE is a solid at ambient conditions and thus presents no unique spill potential problems. If, however, a spill occurred, then normal solids cleanup procedures would have been used. The spill would be scooped up, along with any contaminated soil, and processed in the incinerator, along with the sand used for the trial burns. A front-end loader and shovels were available for this task.

TCB is a liquid at the temperatures expected at NCBC during the trial burn. Therefore, bulk quantities of TCB were contained in 55-gallon drums and placed within a bermed storage area. If a spill occurred, sand or absorbent clay would be placed over the spill. The absorbed material would then be scooped up and processed in the incinerator. Following the trial burns, the remaining inventory of 1,2,4-TCB was processed with sand, whereas the HCE was returned to a bulk chemical distributor.

Where it was found appropriate, additional countermeasures were included in the field setup. The plan specified procedures in the event a spill did occur; however, there were no reportable spills during the trial burn.

E. VERIFICATION SAMPLES

1. Field Sampling

To evaluate the effectiveness of ENSCO's incinerator for treating the sand spiked with 1,2,4-TCB and HCE, Versar collected the following samples according to the sampling plan, except to accommodate a change in the POHC input method (Appendix A, Exhibit 6).

- Feedstock sand
- Treated solid residue (ash drag)
- Stack gas

- Effluent neutralization tank
- Background (clean sand, clean feedstock and its processed ash drag residue and ENT water, tap water, and stack gas sampling premixed reagents).

These sample points are identified in the incinerator process shown in Figure 22. The background samples for the clean feedstock, processed ash drag residue, and ENT water were to show the system was not contaminated before starting the trial burn tests.

The draft trial burn plan called for sampling of the feedstock sand/POHC-mixture at 15-minute intervals. As discussed in Section III.A, the POHC feed to the incinerator was modified to allow direct feeding rather than first mixing it with the sand. Therefore, the sand was not sampled during the trial burn tests. (Background samples were taken as discussed in Section V.D).

The residence time of the solids in the rotary kiln was estimated at 30 minutes at a soil feed rate of 4 tons per hour; therefore, sampling of treated residue was delayed a similar time duration after initiation of each test run. Each composite sample was then homogenized, after which a final aliquot sample was taken for analysis. The ash drag solids grab samples were taken from the treated soil in the rolloff box. Actual times for the grab samples for each test burn are shown in Section IV.D.2.

The sampling approach for collection of particles and gas samples was to use a Method 5 (M5) and Modified Method 5 (MM5) sample collection system, respectively. Each sample collection system was operated simultaneously. Each probe traverses the stack according to procedures established in Appendix A of the EPA Reference Method 2 in 40 CFR 60. Two 4-inch flanges are located 90 degrees apart, approximately 6 feet below the top of the stack for these probes. Isokinetic sampling was established by sampling at flow rates equal to the stack gas velocity along specific points inside the stack. Estimated total stack sampling time was 240 minutes.

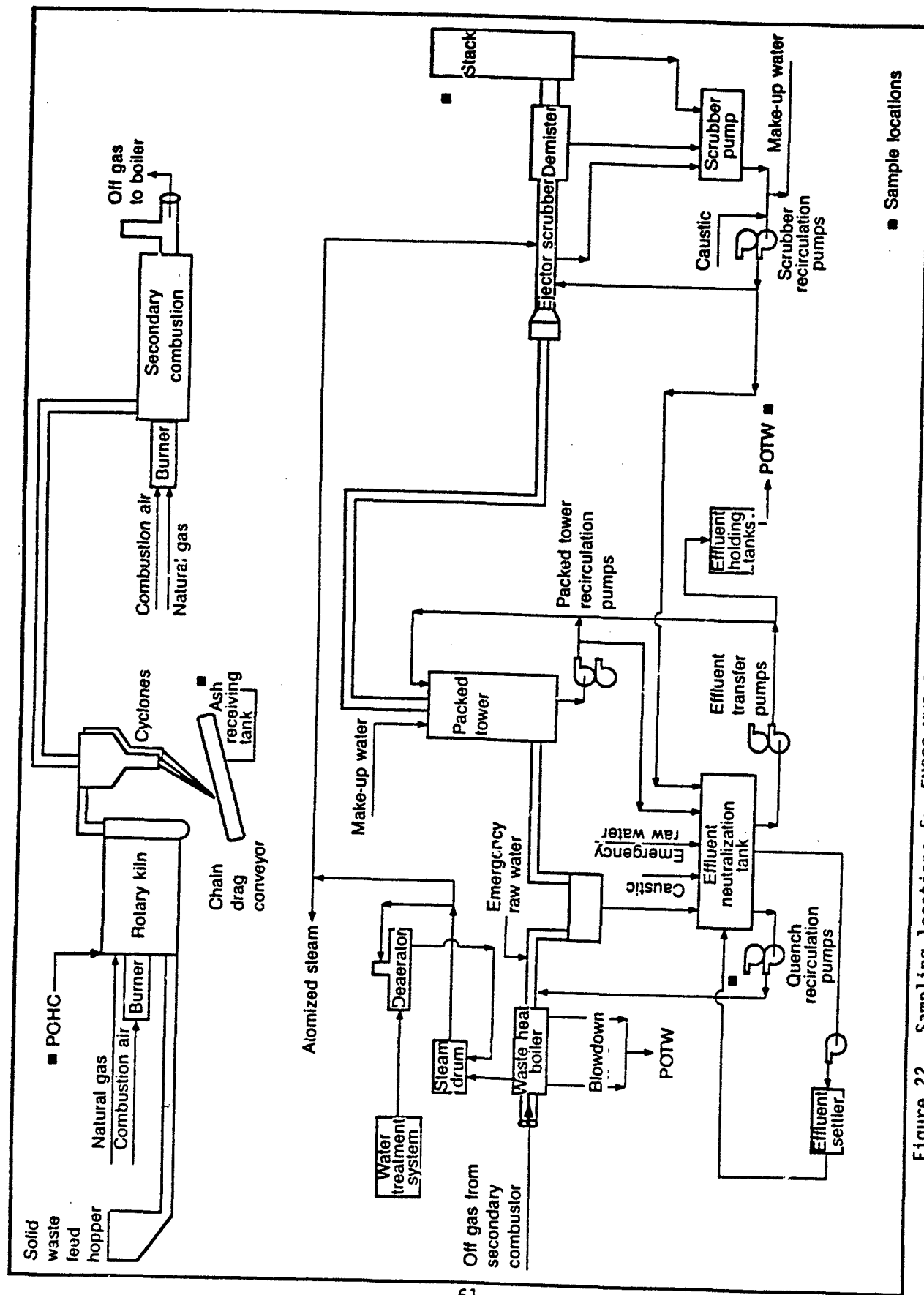


Figure 22. Sampling locations for ENSCO MWP-2000 incinerator system during trial burn.

9-8823

Two sampling trains were needed for stack gas samples. EPA M5 was used for particulate sample collection while MM5 was used for POHC collection. The MM5 sampling train is shown in Figure 23. Functionally, the only difference between the two is that an XAD resin module is placed in the MM5 train upstream of the impingers to sorb the POHC in the gas sample. Although particulates could be measured in the MM5 train, EPA Region IV was concerned that the drying of the particulate filter would drive off some of the POHC collected on it, thus giving a high bias to the DRE calculation. Therefore, the particulate and the POHC had to be measured independently.

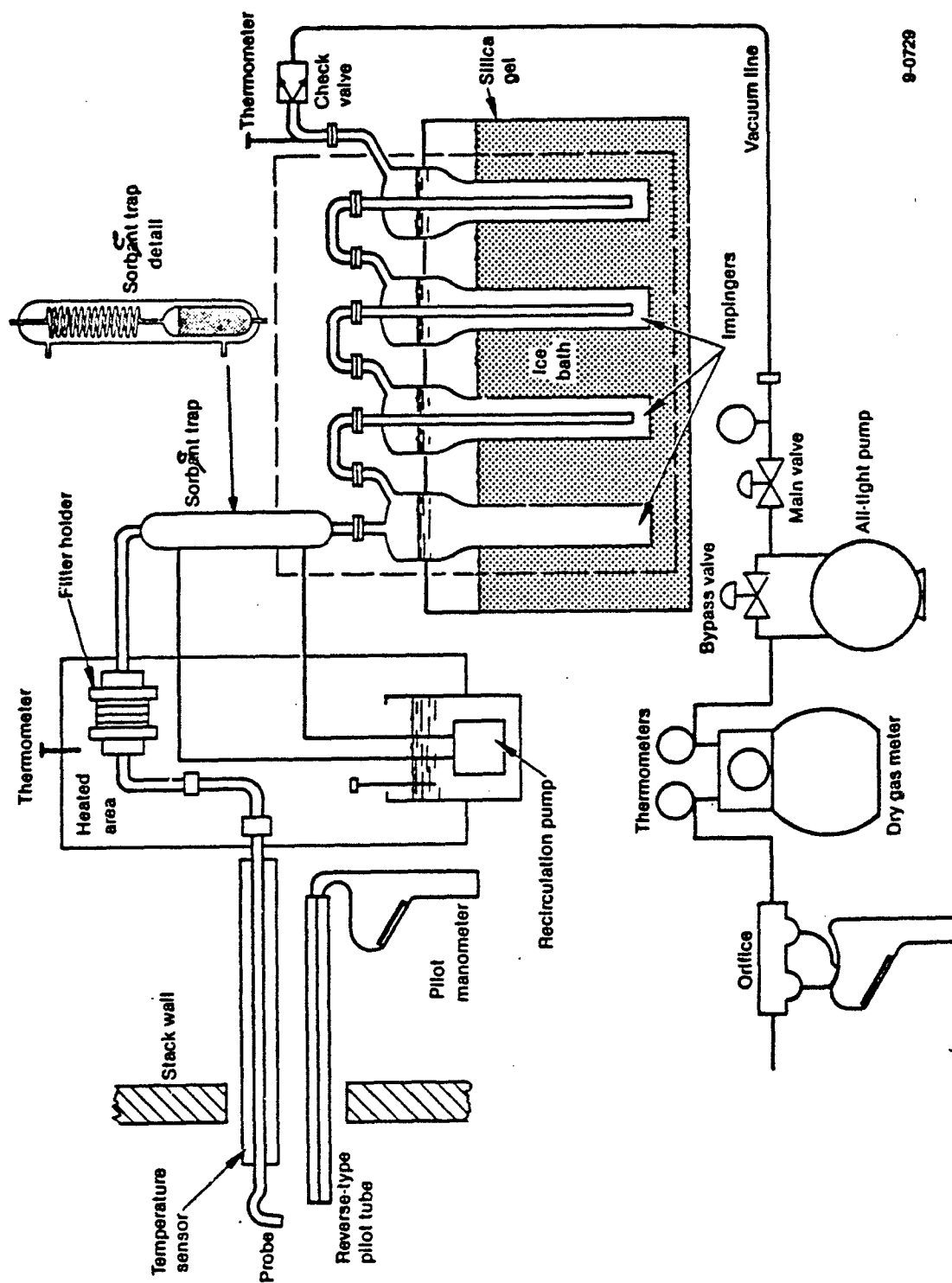
Water samples from the ENT were collected after each test run. Samples were obtained via a valve located just downstream of the neutralization tank circulation pump. The water in the ENT is constantly recirculated and would represent water during the entire test run. Before taking each sample, the sample tap was flushed of any potential stagnant fluid.

The sample of water to be discharged to the POTW was obtained from a sample tap located immediately after the water exits carbon adsorption, but before the POTW holding tanks. The blank water sample was obtained from a supply water tap.

Sample collection and handling procedures were in accordance with EPA methods or acceptable protocols current at the time of the tests. Specific samples taken and methods/protocols followed are discussed in Section IV.D.

2. Shipping

All samples collected during the trial burn were packaged and shipped to the analytical laboratory in accordance with U.S. Department of Transportation regulations. To meet time constraints, Federal Express shipped all samples to the laboratory.



9-0729

Figure 23. Modified Method 5 sampling train.

3. Operating Parameters

The regulations for trial burn testing require continuous monitoring of contaminant mass flow rate and combustion temperature, as well as carbon monoxide (CO), carbon dioxide (CO₂), and oxygen (O₂). In addition to these parameters, the RCRA interim regulations require monitoring of the air feed rate. The objectives for precision, accuracy, and completeness of data for these parameters, identified above, are given in Table 3.

F. ANALYTICAL LABORATORY

1. POHC Screening

To ensure pure supplies of the two POHCs (1,2,4-TCB and HCE), a sample of each planned surrogate supply was collected, split, and sent to the INEL and ITAS Analytical Laboratories for analysis. After the analysis, it was determined that schedule delivery problems precluded use of the HCE from the original source used in the screening process. Because of this change, the initial analytical screenings for HCE are not relevant and will not be reported. A high purity source was located, and the concentration results for the POHC container samples for each test run were determined for use in the incinerator DRE evaluation (see Section V.B).

The INEL sample was further split to compare two replicates of 145 mg each by GC/MS analysis. One replicate showed a peak attributed to 1,2,4-TCB with no detectable impurities. The other replicate showed a peak due to 1,2,4-TCB with a very low detectable indication of a dichlorobenzene isomer (less than 10^{-4} percent). The ITAS analysis confirmed the INEL results that the 1,2,4-TCB was pure.

2. Field Samples

Because of the limited objectives of the trial burn, laboratory analysis of soil, water, and stack gas MM5 samples was necessary only for the two surrogate organic compounds, 1,2,4-TCB and HCE. The stack gas M5 samples were analyzed for hydrochloric acid (HCl) and particulates. Table 4 presents

TABLE 3. QUALITY ASSURANCE OBJECTIVES FOR INSTRUMENTATION PRECISION, ACCURACY, AND COMPLETENESS FOR MWP-2000 INCINERATOR
SYSTEM COMBUSTION AND OPERATING PARAMETERS DURING TRIAL BURN AT NCBC

Parameter	Method of Measurement	Precision ^a (Percent)	Accuracy ^b (Percent)	Completeness ^c (Percent)
Rotary kiln gas temperature	Thermocouple	5	5	90
SCC temperature	Thermocouple	5	5	90
Carbon monoxide	Beckman Infrared detector	1 percent of full scale	1 percent of full scale	90
Carbon dioxide	NDIR ^d	1 percent of full scale	1 percent of full scale	90
Oxygen	Micro-fuel cell	1 percent of full scale	1 percent of full scale	90
Kiln air feed rate	Annubar	5	5	90
SCC air feed rate	Annubar	5	5	90
Soil mass feed rate	Load cell	5	10	90

a. Precision is a measure of mutual agreement (or variability) among individual measurements of the same property, usually under prescribed similar conditions and usually expressed in terms of the standard deviation. Various measures of precision exist, depending on the prescribed similar conditions.

b. Accuracy is the degree of agreement of a measurement (or an average of measurement of the same parameter), X , with an accepted reference or true value, T , usually expressed as the difference between the two values, $X-T$, or the difference as a percentage of the reference or true (standard) value, $100(X-T)/T$. Accuracy is a measure of the bias inherent in the system.

c. Completeness is a measure of the quantity of valid data obtained from a measurement system compared to the quantity that was expected to be required to fully evaluate and understand the system under optimum conditions, usually expressed as a percentage.

d. Nondispersive Infrared detector.

TABLE 4. RECOMMENDED EXTRACTION AND ANALYSIS METHODS FOR
NCBC TRIAL BURN SAMPLES

<u>Sample Matrix</u>	<u>EPA Method</u>	
	<u>Extraction</u>	<u>Analysis</u>
Soils	Method 3350 ^a	Method 8270 ^b
Water	Method 3510 ^c	Method 8270
MM5 stack gas	Method 3540 ^d	Method 8270
M5 stack gas	--	Method 325.3 ^e for titrimetric measurement to determine HCl concentration; gravimetric measurement for particulates.

a. Sonication Extraction, Reference 19.

b. GC/MS Method for Semivolatile Organics: Capillary Column Technique, Reference 19.

c. Separatory Funnel Liquid-Liquid Extraction, Reference 19.

d. Soxhlet Extraction, Reference 19.

e. Chloride, Titrametric, Mercuric Nitrate, Reference 27.

the recommended EPA methods for analyzing the above identified constituents according to the sample matrices, i.e. solid, liquid, or stack gas. High-resolution gas chromatograph (HRGC)/(HRMS) was required for POHC analyses of the clean feedstock sand and the treated solid residue (ash drag) samples because undetectable concentrations of 1,2,4-TCB and HCE were expected; however, low-resolution mass spectrometry (LRMS) was specified for the analyses of neat POHC supply samples because of their procured high concentrations. Required method precision accuracy, and completeness are listed for each constituent in Table 5.

ITAS' analytical procedures were in accordance with EPA methods. Laboratory quality assurance was performed in accordance with the trial burn QAPP. The analyses, according to each sample, methods, and results discussion, are presented in Section V.

G. WASTE DISPOSAL

Disposable contaminated nonsoil materials generated during the test burns (e.g., used personnel protective clothing/equipment and sampling equipment) were placed in sealed plastic bags and set aside in a protected area. Those items were processed in the MWP-2000 during routine soil processing which began in November 1987.

Treated solid residue generated from the trial burn was temporarily stockpiled in a clean area (vicinity of plot R12 in Zone A) awaiting disposal as a hazardous waste. The disposal of this material is discussed in Section VI.

TABLE 5. QUALITY ASSURANCE OBJECTIVES FOR SAMPLE ANALYSIS PRECISION, ACCURACY, AND COMPLETENESS
FOR MWP-2000 INCINERATOR SYSTEM TRIAL BURN AT NCBC

<u>Constituent</u>	<u>Matrices</u>	<u>Analysis Method</u>	<u>Method^a Precision</u>	<u>Method^b Accuracy (percent)</u>	<u>Completeness^c (percent)</u>
1,2,4-TCB	Soil, water, MM5	GC/MS ^d	28.1	44-142	95
HCE	Soil, water, MM5	GC/MS ^d	24.5	4-113	95
HCl	M5	Titrimetric ^e	<10	--	95
Particulates	M5	Gravimetric	<10	--	95

a. Expressed as standard deviation in g/L.
b. Expressed as percent recovery.
c. Detected, result must be greater than zero.
d. EPA Method 8270, Reference 19.
e. EPA Method 325.3, Reference 27.

SECTION IV FIELD OPERATIONS

A. DESCRIPTION OF SITE SETUP

The MWP-2000 incinerator system trial burns at NCBC were done at the same location within the former HO storage site that was used for the verification test burns and previously described in Reference 1. A brief discussion is presented herein. Figure 24, a map of the site layout, indicates the various principal test-related facilities. The entire site was isolated from other active facilities on the naval base, and the road and track to the site were inactive during the entire demonstration period. Figure 25 is an aerial photograph of the MWP-2000 incinerator system and surrounding area facilities.

The incinerator operations were located just inside the southeast perimeter of the restricted (HO-contaminated) area (Lot 63), which lies adjacent to Greenwood Avenue and Track D. This location was earlier identified to have dioxin contamination of less than 1 ppb, so it was declared a clean area (Zone 2) for ease of installing the MWP-2000 incinerator system and performing clean soil checkout operation before the verification test burns. The personnel decontamination trailer was located in Zone 2 on the railroad track inside the chain link fence. A gate near the decontamination trailer provided access through the fence to Zone 2 from an unrestricted clean area, designated as Zone 3 (Figure 26). During the trial burns Zone 2 was designated as a Reduced Contamination Area. Access-exit on the Zone 2 side of the decontamination trailer included a covering for rain protection (Figure 27). The support facilities, including office trailers and a personnel break room, were placed in the unrestricted area across the paved road and railroad track to the southeast. Although located on the railroad track inside the chain link fence, the maintenance trailer was in a declared clean zone.

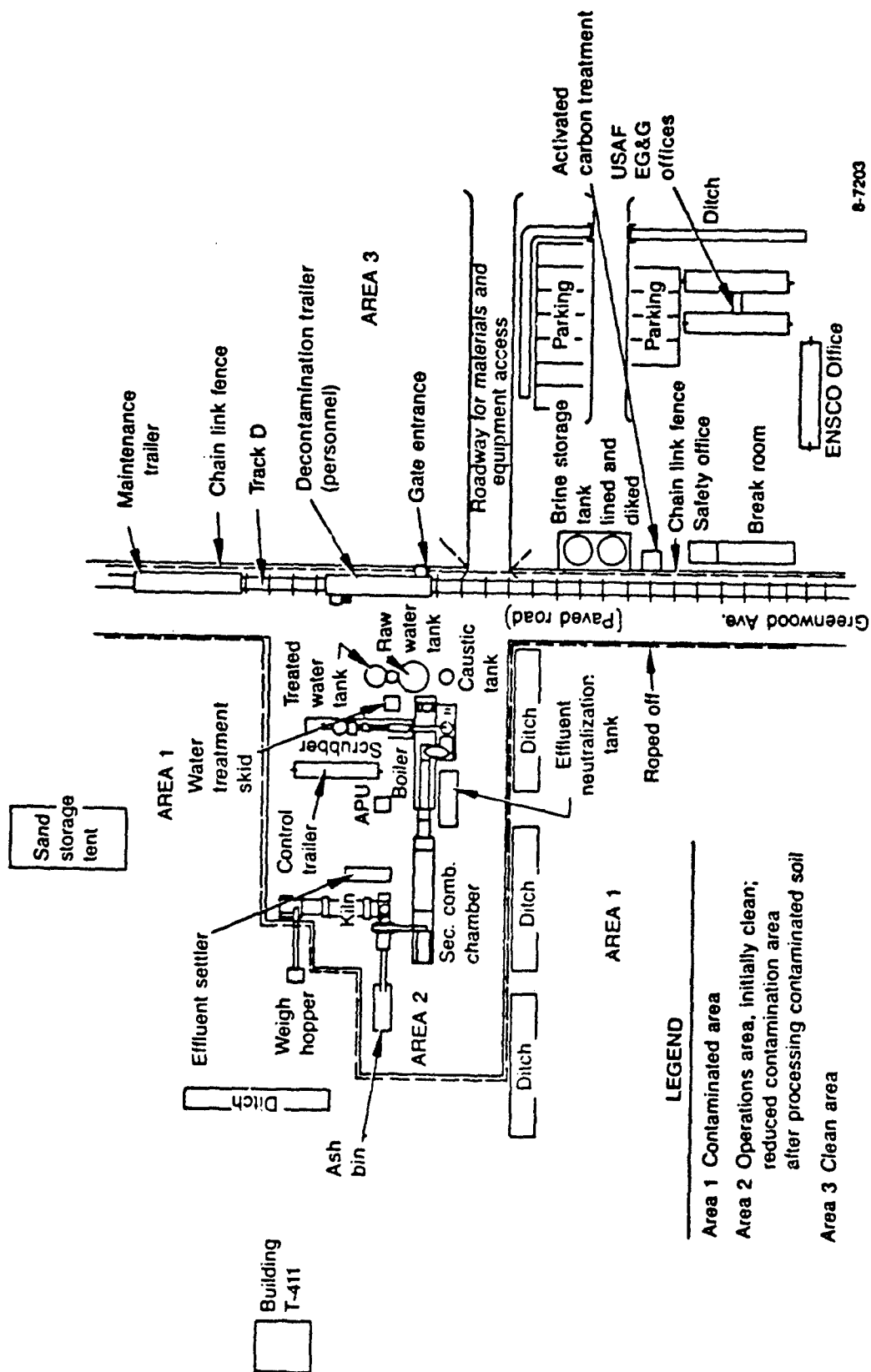


Figure 24. Site layout for MWP-2000 incinerator at NCRC.

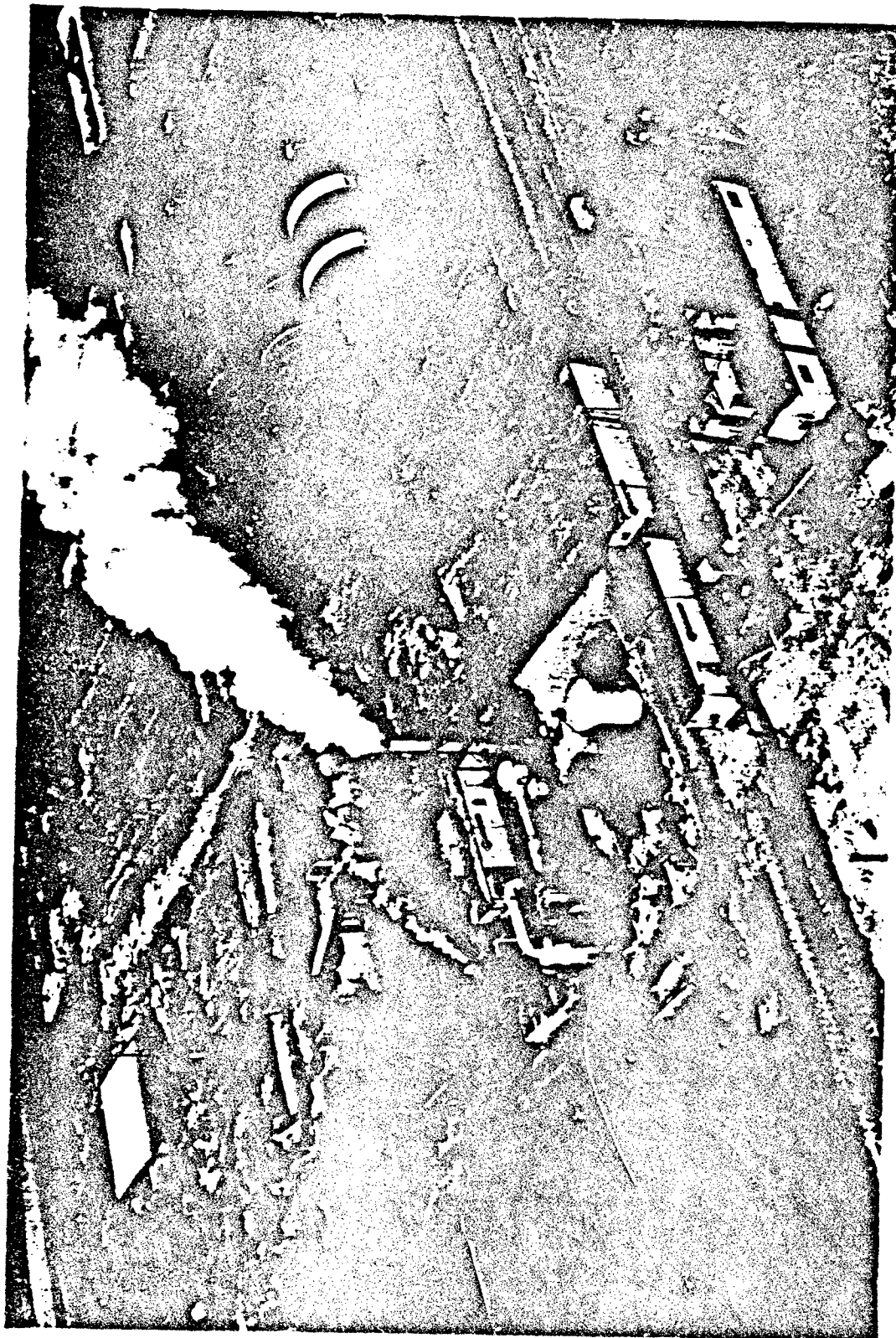


Figure 25. Aerial photograph of the MWP-2000 incinerator system and surrounding area facilities.

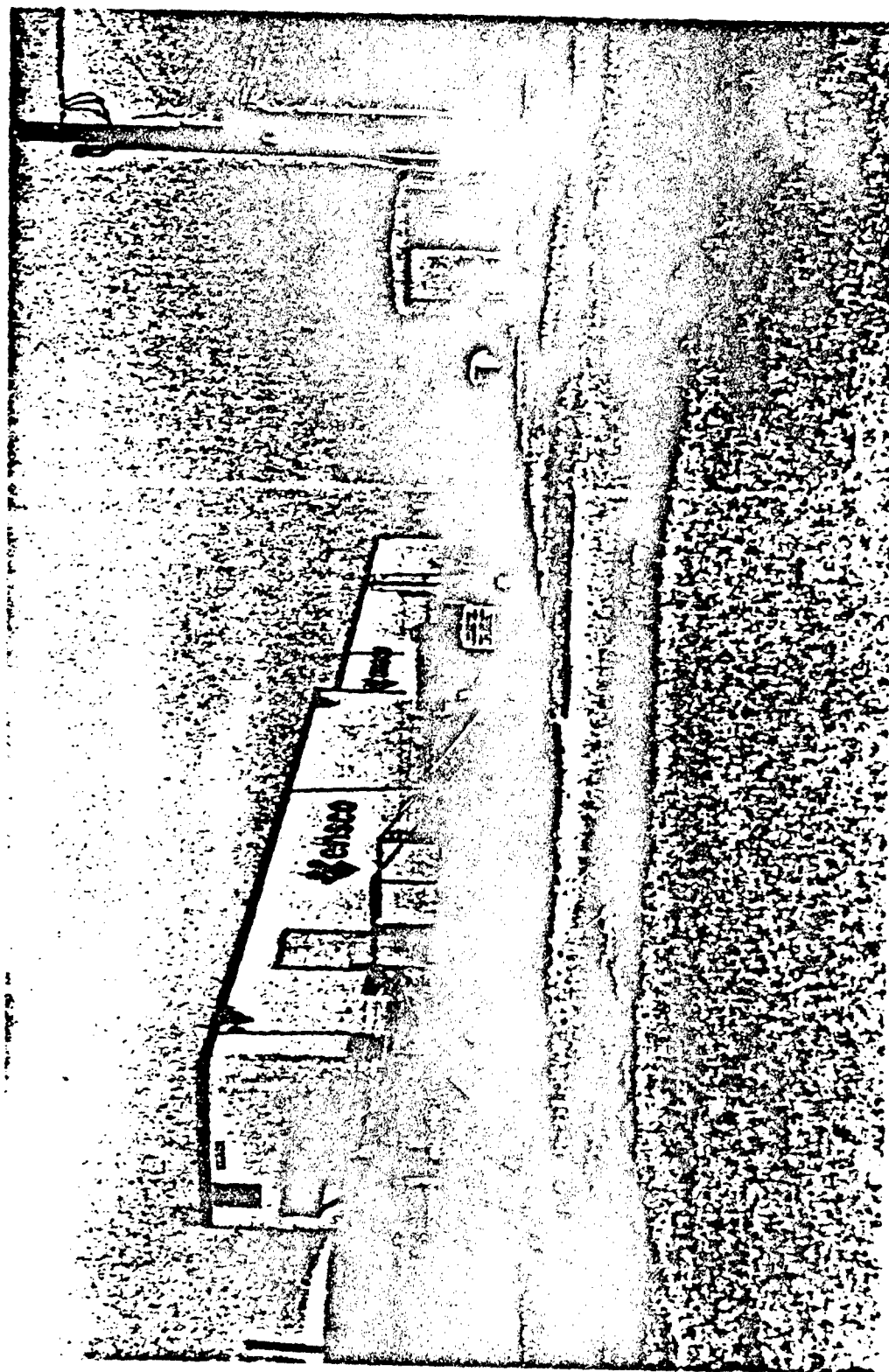


Figure 26. Entrance to site through chain link fence via personnel decontamination trailer.

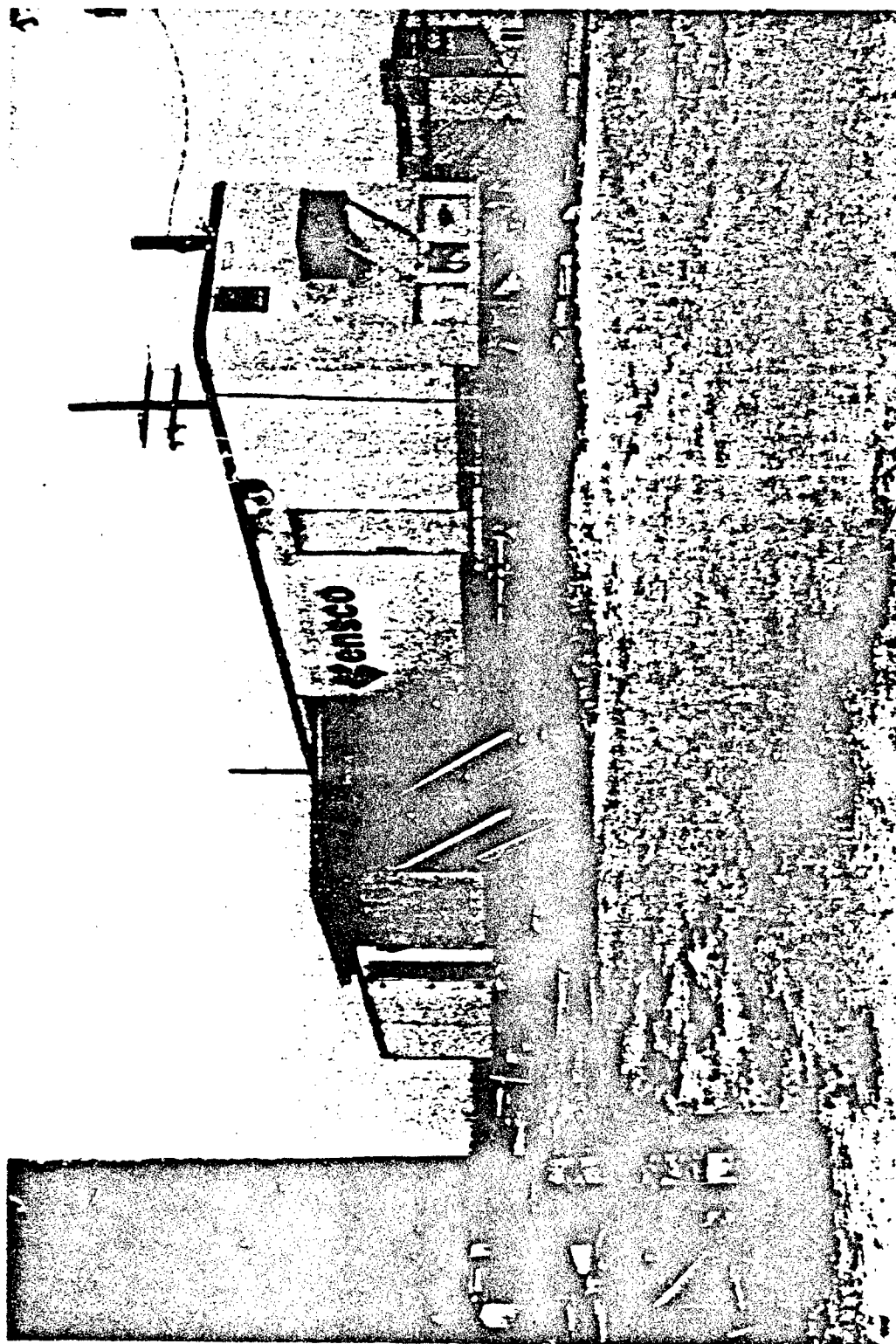


Figure 27. Site side entrance to personnel decontamination trailer.

A number of other supporting process features were NCBC site-specific. During the trial burns, the clean sand was stored within a tent structure large enough to operate a front-end loader. This tent is shown on the right in the aerial photograph in Figure 25 (note: photograph was taken after the trial burns when additional tents were assembled for the soil restoration phase of the demonstration). The control trailer was located in the middle of the U-shape formed by the three flatbed semi-trailers (i.e., kiln, SCC, air pollution control train). In Figure 28, the kiln is on the right of the trailer, and the bottom of the stack is on the left. Raw water pumped from the NCBC wells was stored in two tanks (Figure 29). The caustic tank is shown on the left in same photograph (note the spill dike) while the chemical treatment tank skid is shown in front of the stack. The two storage tanks used to store waste effluent to be released to the NCBC sewer line for POTW treatment are shown in Figure 30. These tanks were set up outside the chain link fence. (Note the spill protection provided by the diked covered ground surface around the tanks.)

Existing utility connections to base systems provided natural gas, water supply, sewer, and electrical power to operate the MWP-2000 incinerator system.

B. FEEDSTOCK

1. Sand Storage and Handling

Approximately 300 tons of clean sand was obtained for the trial burn. This material was stored in a tent shown in Figure 31 to protect the sand from any rain that might occur until the testing was completed. As shown in Figure 24, the location of the tent was near the weigh hopper to simplify the loading process. Loading of the sand to the weigh hopper was done with a front-end loader.

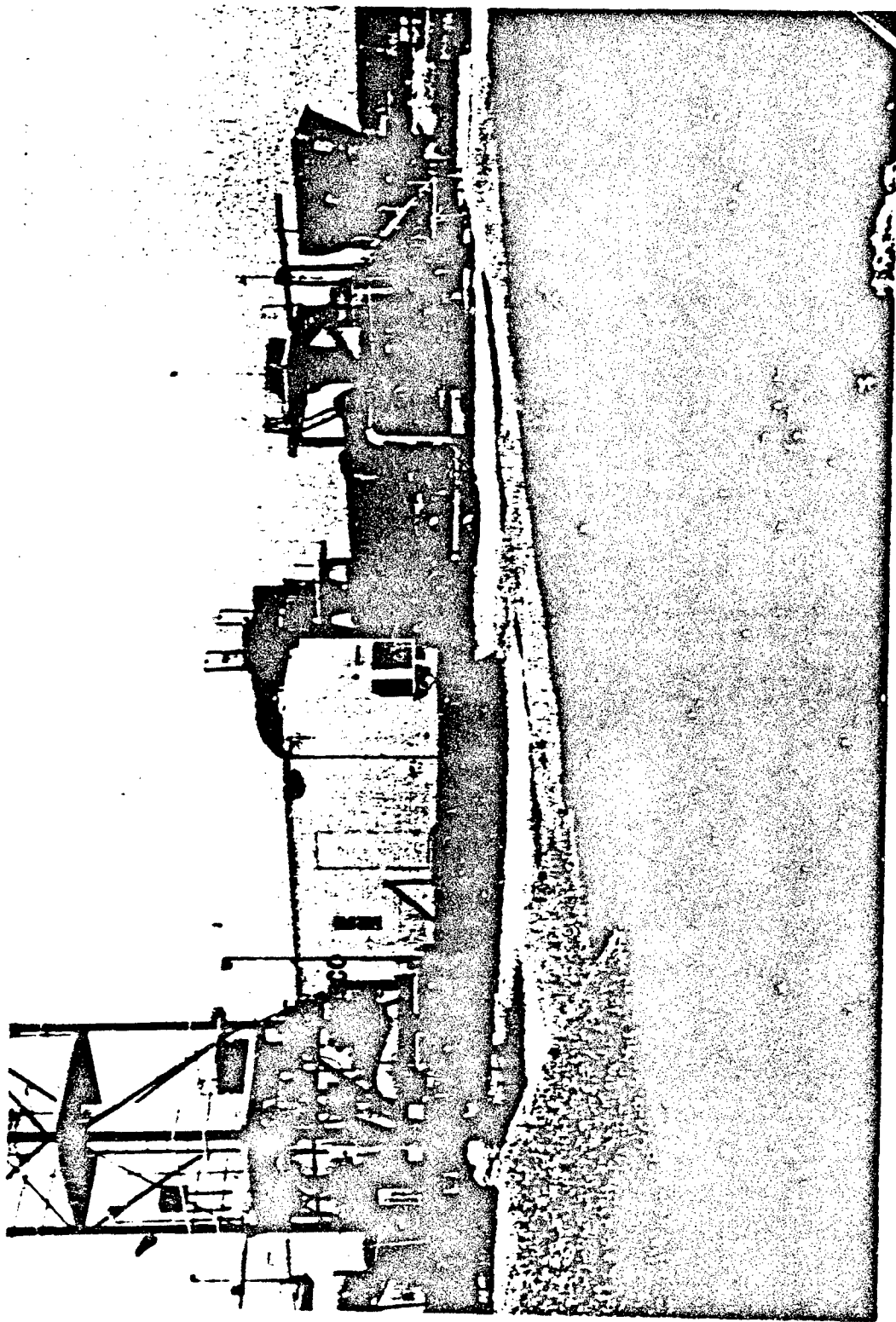


Figure 28. External view of MWP-2000 incinerator system control trailer.

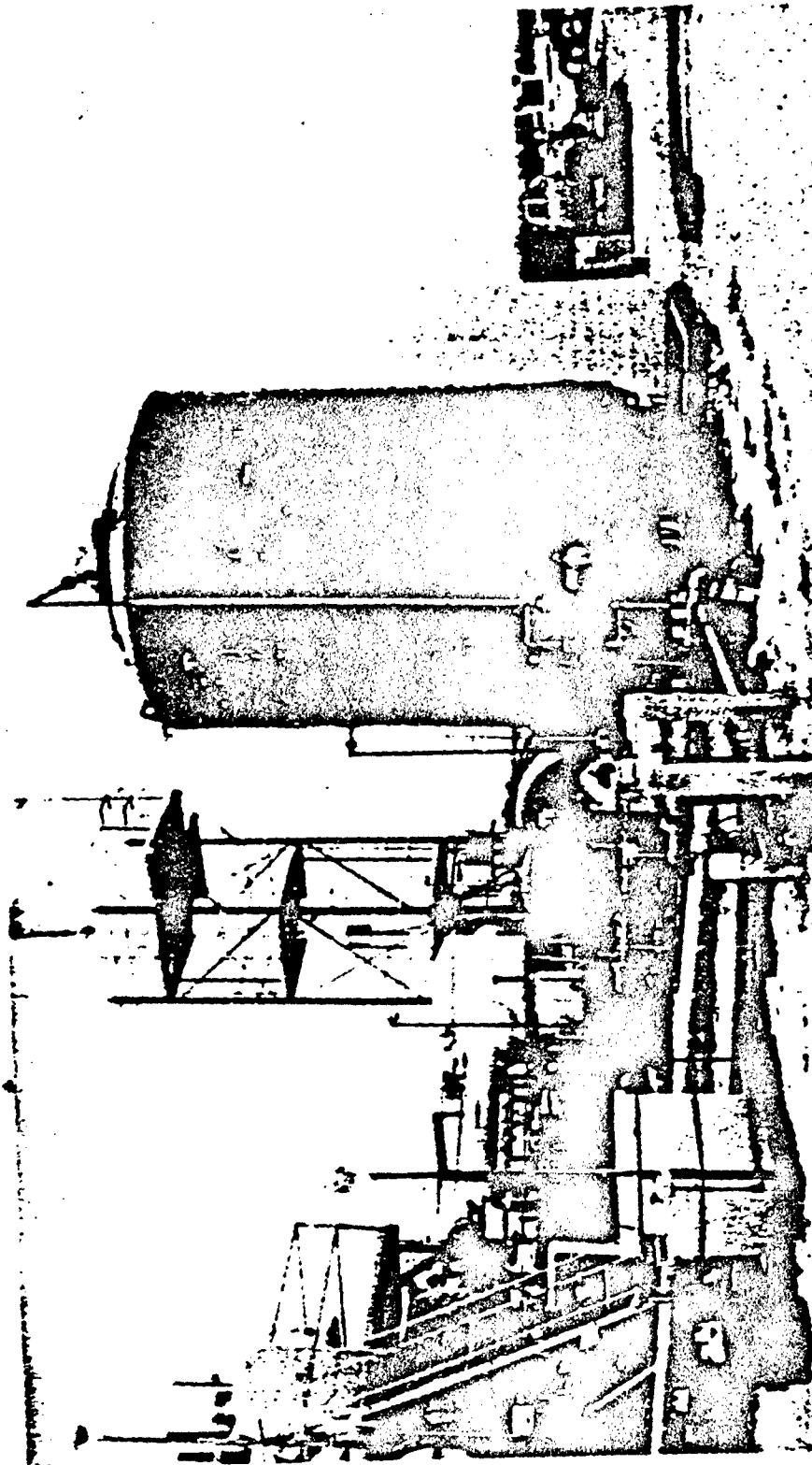


Figure 29. View of raw water supply tanks, caustic tank, and chemical treatment tank skid.

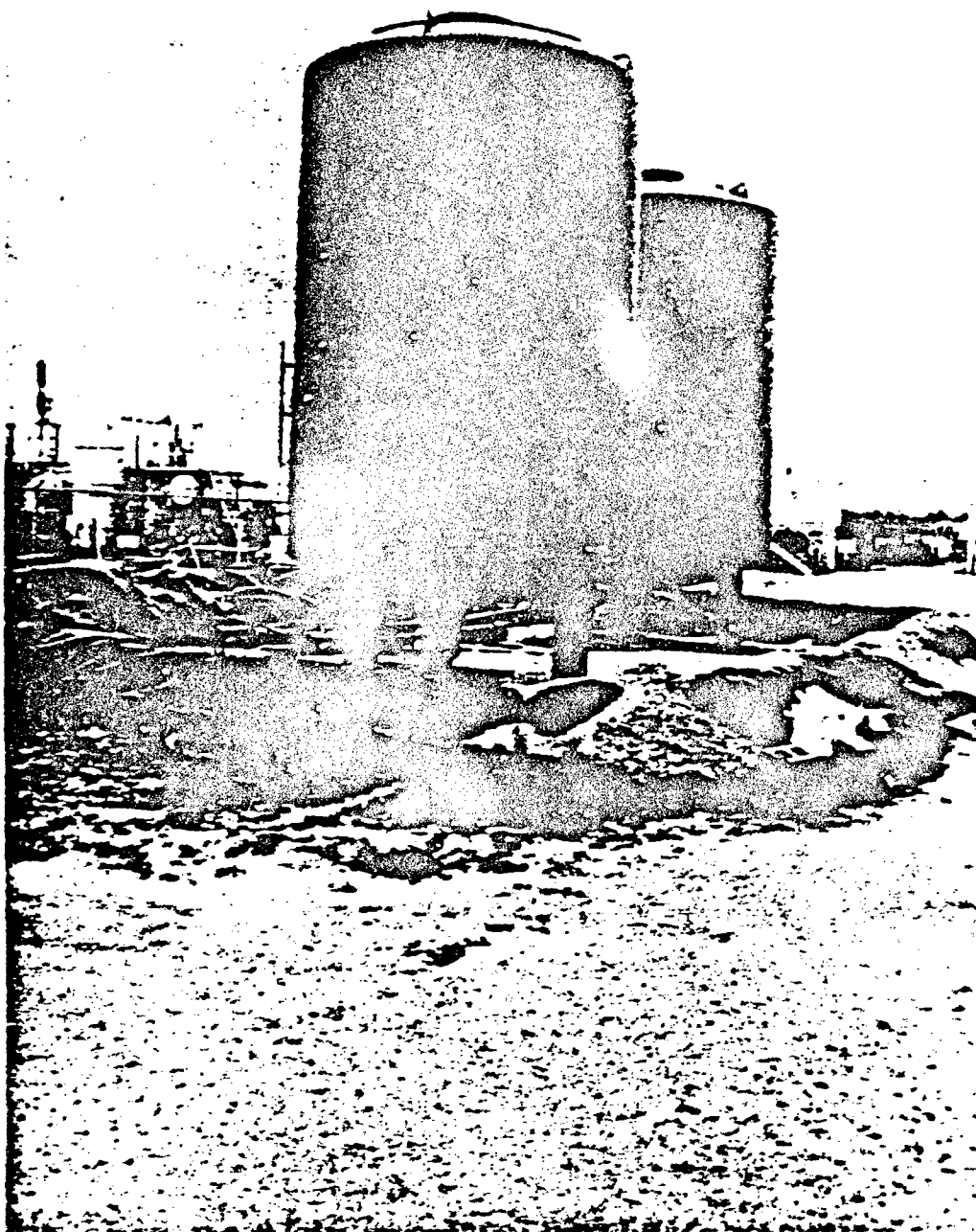


Figure 30. View of waste water storage tanks for POTW.

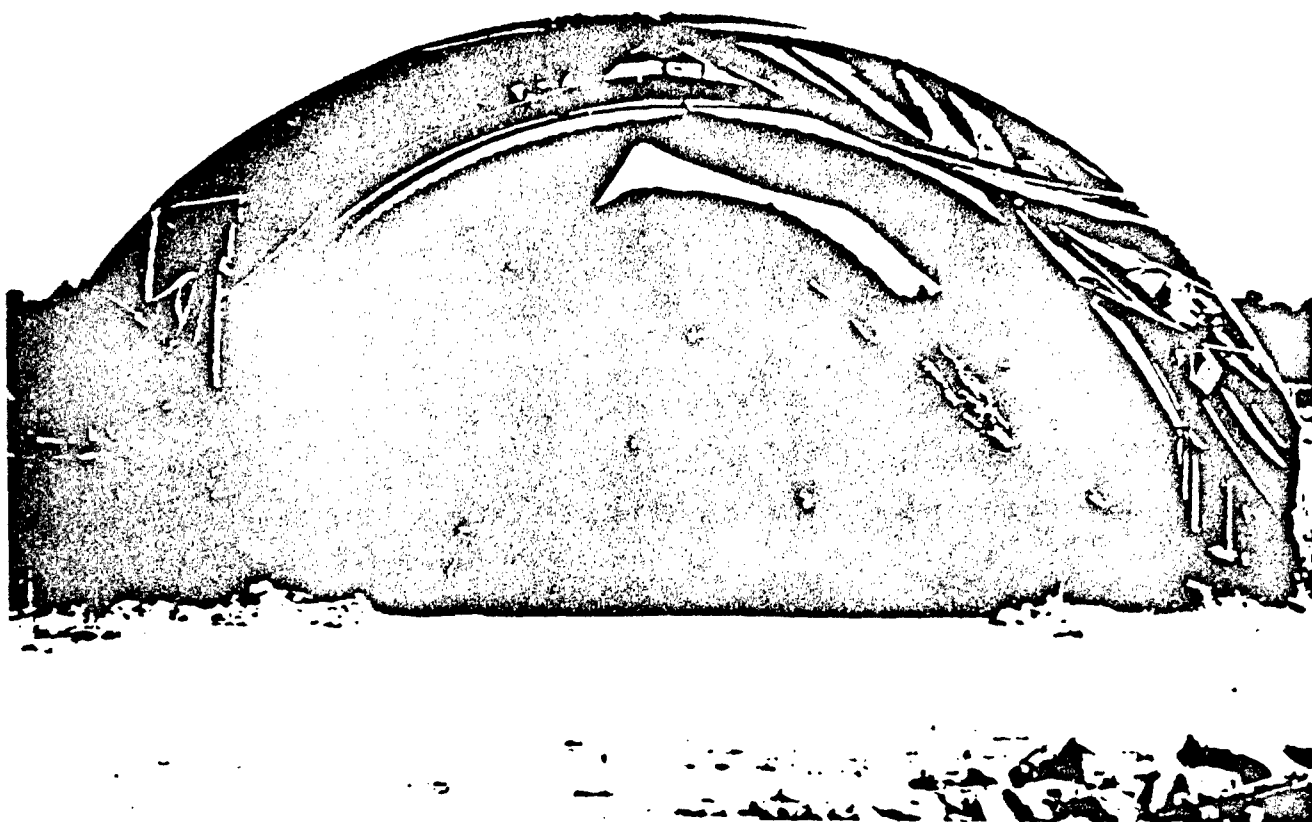


Figure 31. View of clean sand storage tent.

2. POHC Storage and Handling

a. 1,2,4-TCB

The 1,2,4-TCB (99 percent pure) was received from Dyce Chemical of Ogden, Utah, in two shipments of two 55-gallon drums with a total weight of approximately 1100 pounds. The drums were set in an area next to the tent containing the sand. A berm was placed around the drum area to prevent spread of any spills or leakage that might occur from the drums.

In support of the alternate POHC feed method (Appendix A, Exhibit 6), pint-size polyethylene bottles were filled with at least 680 grams of 1,2,4-TCB. A siphon technique was used to transfer the liquid from the drum to each bottle that was set on a scale with a balance beam. From the weighing of 15 empty bottles, the average empty bottle weight was found to be 33.95 grams, with a range of 33.2 to 33.4 grams. Thus, the balance beam was set at 714 grams. As a Quality Control (QC) check, 15 filled bottles from a total of about 150 (10 percent) were randomly picked to be individually weighed for each trial burn run to determine the weight average and distribution of 1,2,4-TCB contents in the bottles. Assuming an empty bottle weighs 34 grams, the following averages and ranges of 1,2,4-TCB were found by this procedure for the three trial burn runs:

<u>1,2,4-TCB Contents</u>	<u>Run 7A</u>	<u>Run 7B</u>	<u>Run 7C</u>
Weight average, grams	708.2	700.5	715.8
Weight range, grams	696-714.5	688-715	707-726

The overall average was 708.2 grams for the 45 bottles checked. Loaded bottles were stored in a box awaiting use in the trial burn run.

b. HCE

The HCE was received from Atlantic and Gulf Resources, Inc. of Piermont, New York, in one shipment of 73 bags, each weighing 55 pounds, for a total of 4,015 pounds. The bags were stacked on skids located next to the tent containing the sand.

In support of the alternate POHC feed method, Ziploc[®] bags, large enough to contain and seal at least 680 grams of HCE, were used to feed this solid POHC. The bags were set on a scale and hand-loaded from one of the shipment bags. The balance beam was set at the target weight. A stack of 15 empty bags was weighed and showed an average bag weight of 7.4 grams. Thus, the balance beam target weight was set at approximately 688 grams. As a QC check, 15 filled bags from a total of about 150 (10 percent) were randomly picked to be individually weighed for each trial burn run to determine the weight average and distribution of HCE contents in each bag. Assuming an empty bag weighs 7.4 grams, the following averages and ranges of HCE were found by this procedure for the three trial burn runs:

<u>HCE Contents</u>	<u>Run 7A</u>	<u>Run 7B</u>	<u>Run 7C</u>
Weight average, grams	682.5	683.0	682.4
Weight range, grams	678.6-687.6	679.6-691.1	680.6-690.6

The overall average was 682.6 grams for the 45 bags checked. Loaded bags were stored in a box awaiting use in the trial burn run.

c. INCINERATOR ACTIVITIES

1. Overall Field Activities

The onsite activities supporting the trial burn began in late April 1987 with the arrival of the ENSCO and Versar personnel teams and representatives from EG&G Idaho and AFESC.

b. HCE

The HCE was received from Atlantic and Gulf Resources, Inc. of Piermont, New York, in one shipment of 73 bags, each weighing 55 pounds, for a total of 4,015 pounds. The bags were stacked on skids located next to the tent containing the sand.

In support of the alternate POHC feed method, Ziploc^R bags, large enough to contain and seal at least 680 grams of HCE, were used to feed this solid POHC. The bags were set on a scale and hand-loaded from one of the shipment bags. The balance beam was set at the target weight. A stack of 15 empty bags was weighed and showed an average bag weight of 7.4 grams. Thus, the balance beam target weight was set at approximately 688 grams. As a QC check, 15 filled bags from a total of about 150 (10 percent) were randomly picked to be individually weighed for each trial burn run to determine the weight average and distribution of HCE contents in each bag. Assuming an empty bag weighs 7.4 grams, the following averages and ranges of HCE were found by this procedure for the three trial burn runs:

<u>HCE Contents</u>	<u>Run 7A</u>	<u>Run 7B</u>	<u>Run 7C</u>
Weight average, grams	682.5	683.0	682.4
Weight range, grams	678.6-687.6	679.6-691.1	680.6-690.6

The overall average was 682.6 grams for the 45 bags checked. Loaded bags were stored in a box awaiting use in the trial burn run.

c. INCINERATOR ACTIVITIES

1. Overall Field Activities

The onsite activities supporting the trial burn began in late April 1987 with the arrival of the ENSCO and Versar personnel teams and representatives from EG&G Idaho and AFESC.

On April 30, 1987, the incinerator system was started up to produce steam. Clean sand was used as feed. No significant incinerator operation problems were encountered. The incinerator system was again operated on May 2, 4, and 5 to obtain background samples. Following this, a readiness review was conducted by the representatives and key personnel from the project organizations. This consisted of reviewing a checklist of activity steps and documentation necessary to start up the incinerator system for the trial burn from the previous cold standby status left from the verification test burns in December 1986.

Also, before any trial burn runs were made, a check for cyclonic flow was performed following procedures for sample and velocity traverses for stationary sources in EPA Reference Method 1 (Appendix A to 40 CFR 60) to satisfy a request made by Region IV staff. Cyclonic flow was not observed.

Preparation of the POHC-spiked sand feedstock was started on April 30. As discussed in Section III.A, this method was unsuccessful. The alternate method finally used (Appendix A, Exhibit 6) was verbally presented to and accepted by EPA Region IV staff on May 5. Verbal permission to begin testing was received from EPA on May 7, 1989. On May 8, an EPA representative returned to the site to witness the tests and the first trial burn test run was initiated; however, weather conditions (lightning) developed such that sampling personnel could not safely perform on the stack, and the run was terminated between the first and second stack sample traverses. Attempts were also made on May 9 and 10, but gas sampler leakage problems and weather conditions precluded any test runs. Leakage problems were caused by faulty seals at a flange and a quick-disconnect; these were corrected. Following a successful leak check on May 11, Test Run 7A¹ was performed without any notable or unusual events. Test Run 7B followed on May 12 also without any unusual events.

1. Note that the trial burn runs were designated as Runs 7A, 7B, and 7C to avoid any possible confusion with the previous tests conducted in December 1986.

The test run on May 13 was voided because of an incorrect MM5 configuration alignment. The condenser was inadvertently placed downstream of the XAD resin column, which precluded proper cooling of the gas stream ahead of the filter. A test run was started on May 14, but weather conditions forced an early termination because of personnel safety on the stack.

The final run, Test 7C, was performed on May 16. All three test runs were made at the approximate same operating parameters to provide a triplicate replication. The following provides the average feed rate duration of POHC feeding, duration over which sampling was performed, and date each test burn run was performed:

<u>Test Burn Run</u>	<u>Date Performed</u>	<u>Average Sand Feed Rate (tons/hour)</u>	<u>POHC Feed Duration (hours)</u>	<u>Gas Sampling Collection Time (hours)</u>
7A	May 11	5.1	7.8	4.0
7B	May 12	5.3	6.8	4.0
7C	May 16	5.3	6.8	4.0

The previously planned 2-hour stack gas sample was lengthened to be no less than 3 hours, based on Reference 22, which indicates that a minimum 3-hour MM5 sample is preferred to obtain a minimum stack gas sample volume of 3 m³. As shown by the above data, a 4-hour duration was used for the stack gas sample collection. This lengthened the overall duration for each trial burn run, inclusive of preparation and posttest checks. The POHC feed started well ahead of the stack gas sample collection and ceased at the same time the gas sample collection was completed.

The test plan originally called for two sets of tests: one test set was planned for 4 tons/hour and another at a maximum feed rate which was presumably 6 tons/hour. Run 7A was actually run at 5.1 tons/hour. This higher than planned feed rate was caused by operator inexperience and manual calculation of the feed rate; the lightning storm on May 10 caused some electronic damage to the weigh hopper load cells. As a result, it was

decided to run Test 7B at the same conditions as Run 7A. The samples were sent to ITAS Laboratories for analysis. Preliminary results were received on Friday, May 15. The results of those tests indicated that the MWP-2000 had passed the six nines DRE requirements. Therefore, it was decided to perform Run 7C at the same test conditions in order to complete the required triplicate test. Had Run 7A or 7B failed, then the incinerator operating conditions would have been changed to increase the chances of success.

The second series of tests--Runs 8A, 8B, and 8C--that were planned for the maximum possible feed rate were cancelled. The numerous problems and schedule delays encountered during Test 7 indicated that a substantial effort would be required to successfully complete Test 8. Additionally, operations personnel observed that, based upon the verification test burns in December 1986 and the operating experience gained during these trial burns, consistently higher feed rates above 5.3 tons/hour were not likely. The cost and effort to complete a higher feed rate test did not justify the unlikely potential benefits.

Following the final trial burn run, the MWP-2000 incinerator system was shut down and placed in cold standby to await EPA authorization to commence routine operations for soil restoration at the site. Because analysis of the collected samples, evaluation of the data, presentation of the data to EPA Region IV, and subsequent AFESC/EG&G Idaho interaction with the regulatory agency could involve a considerable period of time, the ENSCO crew was reduced to a size sufficient for security and maintenance.

2. POHC and Sand Feed

a. Test Run 7A

The rotary kiln and SCC were brought up to operating temperature for Test Run 7A on May 11, 1987, at about 0430 in the morning. After resolving some minor problems, clean sand was being fed to the kiln by 0645. POHC feeding began by about 0715, and sand/POHC feed continued until about 1600 in the afternoon. The incinerator system was then cooled down to an idle status.

The sand feed rate shown in Figure 32(a) was calculated manually from the scale readings of the individual loads dumped into the weigh hopper. This was necessary because of a malfunction of the scale signal converter for that day. The recorded weigh hopper sand loadings and sand feed rate calculations are shown in Appendix C.

An electrical power surge, as a result of a lightning strike the day before (May 10), is suspected of corrupting the programmable electronics on the digital weigh hopper scale. This scale is linked to the DAS computer in the control trailer and provided input feed rates at 5-minute intervals. Although the electronic scale weighing mechanism was not affected, the programmable electronic circuitry linked to this mechanism provided values to the DAS that were clearly inconsistent with other known feed rate parameters (e.g., manual scale, auger speed). The anomaly was identified and reported by the system operators during the trial burn run. Because the digital scale could not be corrected during the trial burn run, the backup analog scale (Thurman mechanical type) was used for this day for all feed rate data. The digital scale was reprogrammed and checked on the evening of May 11, and no further anomalies were encountered. The DAS readings for the next two trial burn runs correlated to within 2 percent of the digital scale readings.

The 1,2,4-TCB and HCE containers were pitched in an alternating manner with each POHC type being pitched on an approximate 3-minute interval. According to the pitch log (Appendix L, Exhibit 1), a total of 152 TCB-filled containers and 151 HCE-filled containers were pitched between 0821 and 1554 hours on May 11. Thus, about 237 pounds of 1,2,4-TCB and 227 pounds of HCE were pitched during Test Run 7A.

b. Test Run 7B

The kiln and SCC were brought up to operating temperature for Test Run 7B on May 12, 1987, and were ready at 0545 in the morning. Feed of clean sand to the kiln began by 0645. POHC feeding began at 0830 and sand/POHC feed continued until about 1416 in the afternoon. The incinerator system was then cooled down to an idle status.

Mass Feed Rate

Run 7A

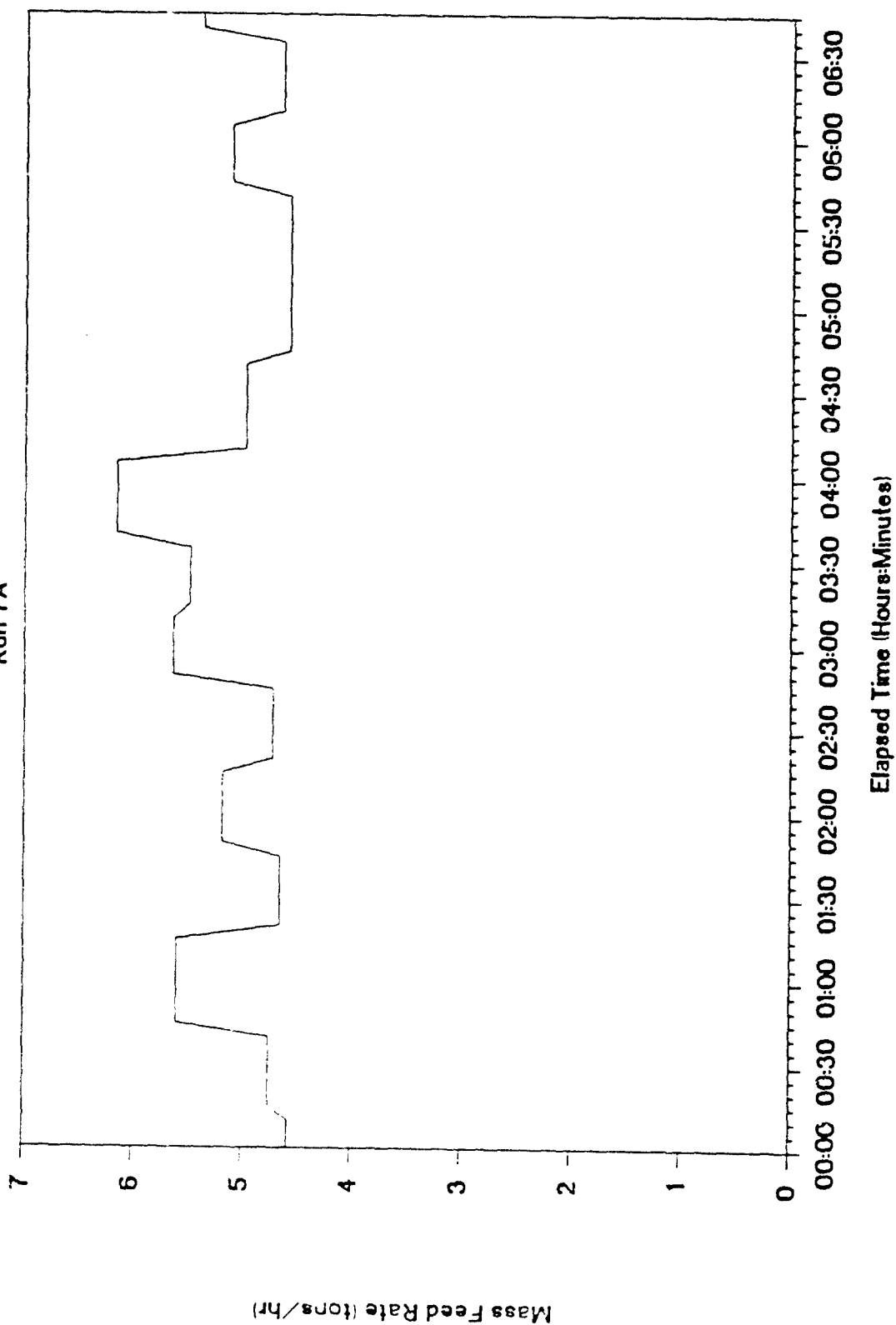


Figure 32. The sand feed rate during NCBC trial burn tests.

The sand feed rate during the test run is shown in Figure 32(b) and was based on DAS readings at 5-minute intervals. The recorded weigh hopper sand loadings are shown in Appendix C, Exhibit 3.

The alternating 1,2,4-TCB and HCE pitch procedure from Run 7A was followed again for Run 7B. According to the pitch log, a total of 115 TCB-filled and 115 HCE-filled containers were pitched over an approximate 5-3/4-hour duration. Thus, about 179 pounds of 1,2,4-TCB and 173 pounds of HCE were pitched during Test Run 7B.

c. Test Run 7C

The kiln and SCC were brought up to operating temperature for Test Run 7C on May 16, 1987, and were ready at 0530 in the morning. Feed of clean sand to the kiln began at approximately 0600. POHC feeding began at 0800, and sand/POHC feed continued until about 1345 in the afternoon. Because the sampling for the test run was over, the sand that had been earlier premixed with the POHCs was then fed to the kiln at this time to treat this waste (see Section III.A). One load of clean sand was then fed to the kiln. The incinerator system was then cooled down to an idle status.

The sand feed rate during the test run is shown in Figure 32(c) and was based on DAS readings at 5-minute intervals. The recorded weigh nopper sand loadings are shown in Appendix C, Exhibit 4.

The alternating 1,2,4-TCB and HCE pitch procedure from the two previous test runs was followed. According to the pitch log, a total of 115 TCB-filled containers and 114 HCE-filled containers were pitched over an approximate 5-3/4-hour duration. Thus, about 179 pounds of 1,2,4-TCB and 171 pounds of HCE were pitched during Test Run 7C.

Mass Feed Rate

Run 7B

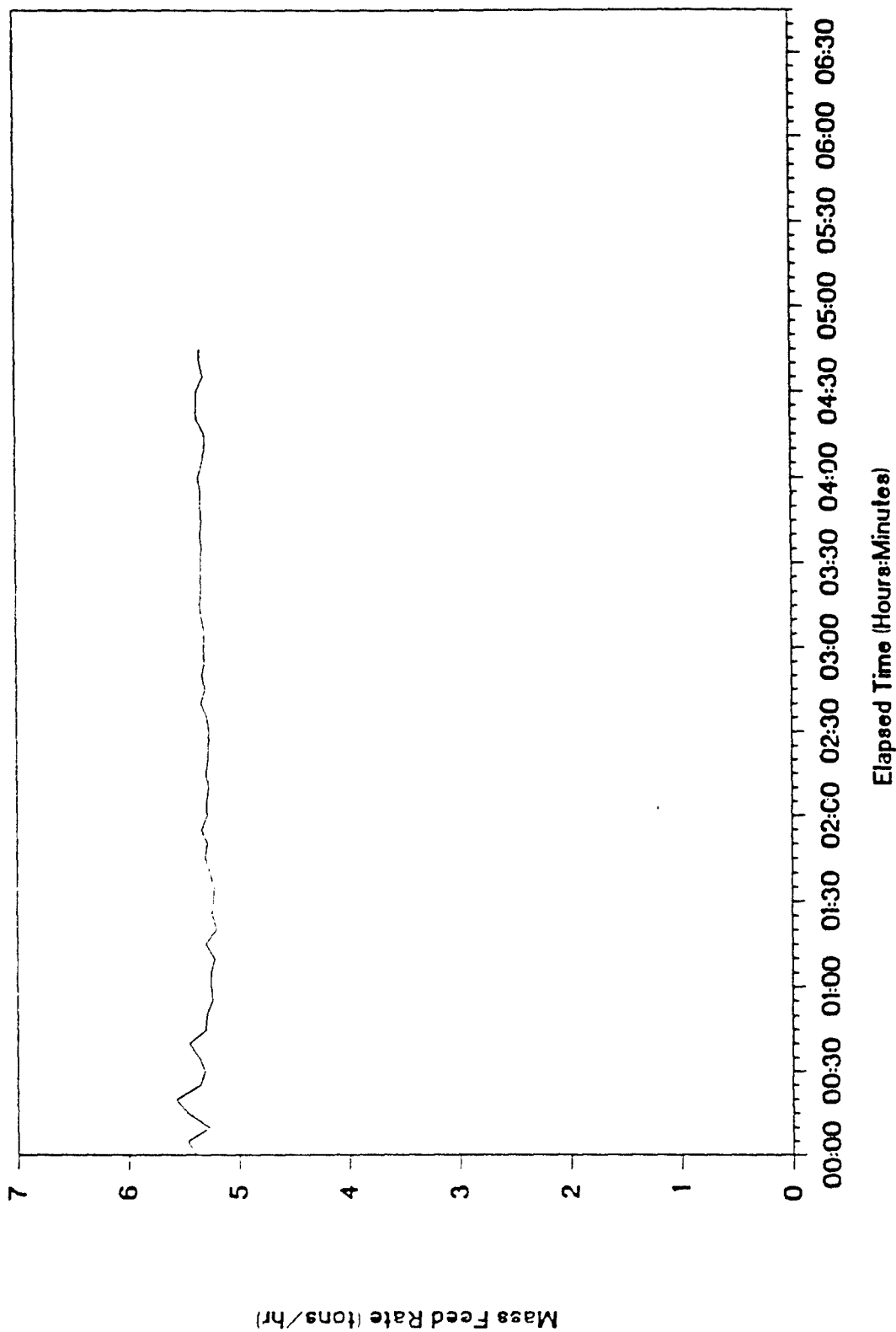


Figure 32. The sand feed rate during NCBC trial burn tests (continued).

Mass Feed Rate

Run 7C

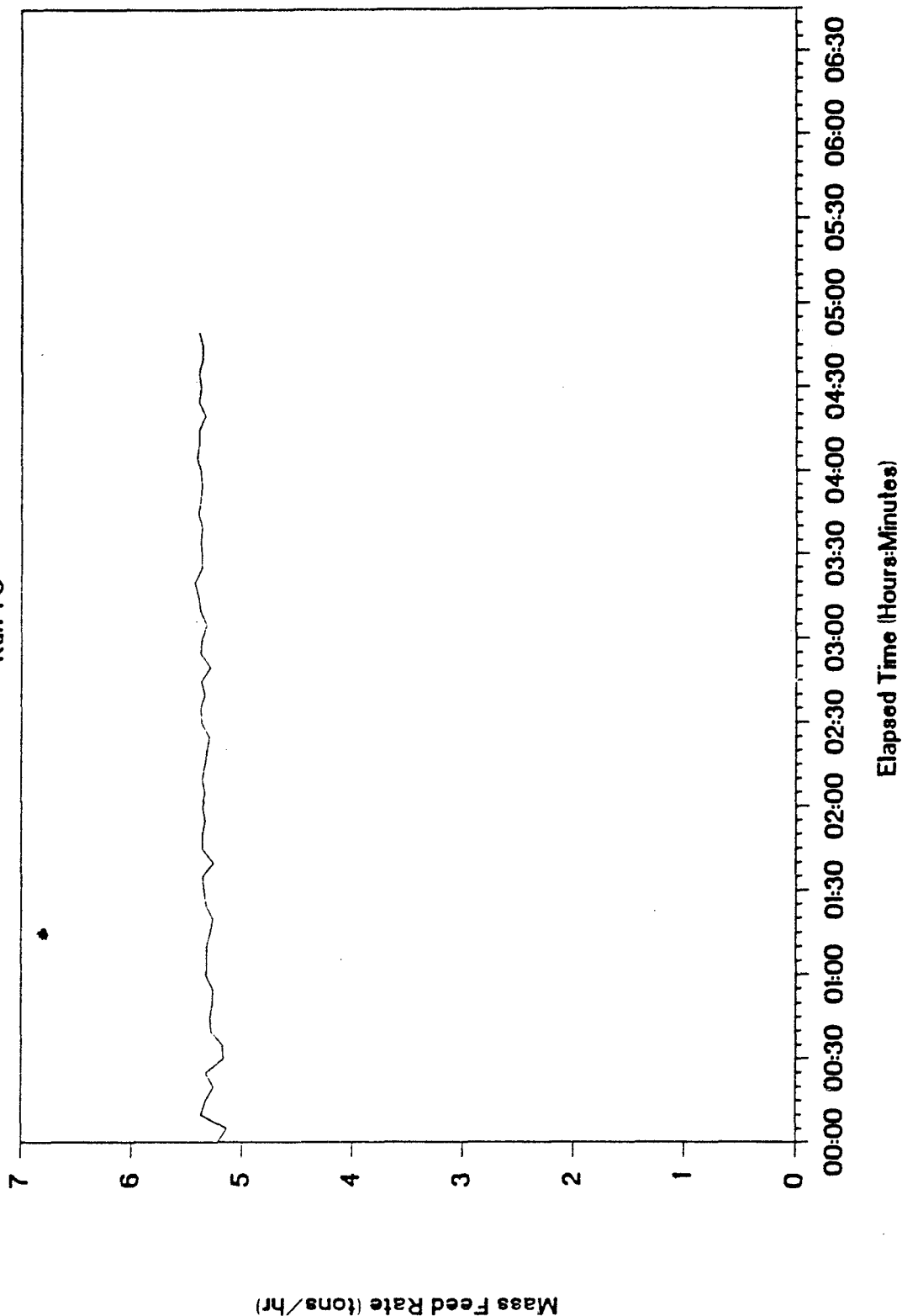


Figure 32. The sand feed rate during NCBC trial burn tests (concluded).

3. Incinerator Operating Conditions

a. RD&D Permit Requirements

The RD&D permit specified three performance standards (POHC DRE, chlorine emissions, and particulate emissions) for the MWP-2000 incinerator system operation at the NCBC. These standards are listed in Section I.B.2. Because the surrogate POHCs were being used in the trial burn in lieu of the 2,3,7,8-TCDD, the DRE standard applied to 1,2,4-TCB and HCE.

The associated permit specified operating conditions (listed in Table 6) to support these performance standards. The permit also specified that, during startup and shutdown of the MWP-2000 incineration system, hazardous waste must not be introduced into the incinerator unless the incinerator is operating within the conditions specified in Table 6. Region IV also specified four minimum conditions (SCC outlet temperature, oxygen concentration in the stack gas, combustion efficiency, residence time), as shown in Table 6, that require the operator to immediately cut off the hazardous waste feed to the incinerator when any of the conditions occur.

b. Trial Burn Test Runs

Three trial burn test runs were conducted to support the sampling requirements discussed further in Section IV.D. The average operating parameters for each test run are summarized in Table 7. The averages of the parameters from all three test runs are summarized in Table 8 for comparison with the planned operating parameters and permit cutoff points. Critical monitored parameters remained within permit compliance requirements, as discussed below.

The kiln outlet gas temperature averages for Test Runs 7A, 7B, and 7C were 1455, 1457, and 1462°F, respectively. For all three runs, the temperature did not vary beyond the range of 1442 to 1480°F

TABLE 6. RD&D PERMIT SPECIFIED OPERATING CONDITIONS FOR MWP-2000
INCINERATOR SYSTEM OPERATION AT NCBC
(at time of trial burn)

<u>Parameter</u>	<u>Operating Range^a</u>	<u>Feed Cutoff Limits^a</u>
Kiln outlet temperature ^b	1200 to 1800°F	--
Kiln pressure	Negative ^c	--
SCC outlet temperature ^b	2150°F	2100°F
SCC pressure	Negative ^c	--
Oxygen concentration in stack gases	--	3% by volume
Combustion efficiency ^d	--	99%
Residence time ^e	1 to 2 seconds	1 second
Recirculation flow rate to packed tower	--f	--
Recirculation flow rate to scrubber	--f	--

a. Permit requirements from an appendix in Reference 1.

b. As measured by outlet gas thermocouple.

c. To control fugitive emissions from combustion units.

d. As measured by $100 \times \text{CO}_2 / (\text{CO}_2 + \text{CO})$ where CO and CO₂, respectively, are the carbon monoxide and carbon dioxide concentrations in the stack gases.

e. As calculated from mass flows and gas temperature.

f. Shall be maintained to meet scrubber efficiency requirements.

TABLE 7. INCINERATOR PROCESS AVERAGE OPERATING PARAMETER RESULTS FOR EACH OF THREE TRIAL BURN TEST RUNS AT NCBC

Parameter	Units	Test Run ^a		
		7A	7B	7C
Test date	--	5/11/87	5/12/87	5/16/87
Nominal feed rate	tons/hr	5.1	5.3	5.3
Kiln outlet gas temperature	°F	1455	1457	1462
Secondary combustor gas outlet temperature	°F	2156	2157	2158
Gas residence time in secondary combustor	sec	1.46	1.66	1.69
Heat input	MJ/hr	39,314	40,002	39,801
Quench exit temperature	°F	171	171	174
Quench water flow rate	gpm	73.9	75.0	75.2
Packed tower pressure drop	in. H ₂ O	10.41 ^b	5.45	5.63
Recirculation rate	gpm	146	128	122.8
pH (quench recycle)	Standard units	6.0	7.8	7.1
Stack exit velocity (MM5)	ft/sec	76.27	76.1	80.6
Stack exit velocity (M5)	ft/sec	73.27	72.9	76.0
Stack temperature	°F	186	185	187
pH (stack condensate)	S.U.	3.7	4.3	4.6
Oxygen (CEM)	percent	5.82	5.68	5.61
Carbon dioxide (CEM)	percent	8.22	8.11	8.44

TABLE 7. INCINERATOR PROCESS AVERAGE OPERATING PARAMETER RESULTS FOR EACH OF THREE TRIAL BURN TEST RUNS AT NCBC (CONCLUDED)

Parameter	Units	Test Run ^a		
		7A	7B	7C
Carbon monoxide (CEM)	ppm	3.66	3.86	0.52
Combustion efficiency ^c	percent	99.9955	99.9952	99.9994

a. Average of readings taken during each run.

b. Erroneous because the inlet pressure was reading low (actual pressure drop was 5 to 6 inches of H₂O).

c. As measured by $100 \times \text{CO}_2 / (\text{CO}_2 + \text{CO})$ where CO and CO₂, respectively, are the carbon monoxide and carbon dioxide concentrations in the stack gases.

TABLE 8. COMPARISON OF INCINERATOR AVERAGE OPERATING PARAMETER DATA WITH
PLANNED OPERATING PARAMETER VALUES FOR THREE TRIAL BURN TEST
RUNS AT NCBC

Parameter	Units	Planned Range or Setpoint ^a	Average Test Value ^b
Nominal soil feed rate for Test 7	tons/hr	4.0	5.23
Nominal soil feed rate for Test 8	tons/hr	5.0	Not performed
Soil residence time (min)	min	20 to 60	20
Kiln combustion air flow rate	lb/min	120	178
Kiln outlet gas temperature ^c	°F	1350 to 1800	1458
Kiln pressure ^c	in. H ₂ O	Negative	-0.244
Secondary combustor air flow rate	lb/min	300	288
Secondary combustor outlet gas temperature ^c	°F	2100 minimum	2157
Secondary combustor pressure	in. H ₂ O	Negative	-2.56
Gas residence time in secondary combustor ^d	sec	1 to 2	1.60
Boiler outlet gas temperature	°F	450	486
Boiler steam pressure	psig	220 to 240	231
Boiler makeup water flow rate	gpm	20 to 30	40.1
Quench recirculation flow rate	gpm	100	74.7
Quench outlet gas temperature	°F	190	172
Packed tower recirculation flow ^e	gpm	170	132.3
Packed tower makeup water flow	gpm	15	3.23
Scrubber recirculation flow rate ^e	gpm	40	36.7
Scrubber nozzle steam pressure	psig	150	205

TABLE 8. COMPARISON OF INCINERATOR AVERAGE OPERATING PARAMETER DATA WITH PLANNED OPERATING PARAMETER VALUES FOR THREE TRIAL BURN TEST RUNS AT NCBC (CONCLUDED)

Parameter	Units	Planned Range or Setpoint ^a	Average Test Value ^b
Stack gas O ₂	percent (by volume)	3 minimum	5.70
Stack gas CO ₂	percent (by volume)	Not specified	8.26
Stack gas CO	ppm	Not specified	2.68
Combustion efficiency ^c	percent	<99.0	<99.996
HCl emissions ^f	kg/hr	>1.8	0.060
Particulate matter ^f	mg/dscm	>180	38.95

a. Values from Table 1.

b. Average of test data for Test Runs 7A, 7B, and 7C.

c. Permit compliance parameter, see Table 6.

d. Permit compliance parameter; cutoff at 1 second.

e. Permit compliance parameter; no specific value given other than parameter shall be maintained to meet scrubber efficiency requirements (Table 6).

f. Permit compliance parameter based only on sample analysis results.

(Figure 33). This operation was well within the planned range of 1350 to 1800°F (Table 6). The gas pressure remained negative at all times during the test runs (Figure 34), as required (Table 6).

The secondary combustion outlet gas temperature averages for Test Runs 7A, 7B, and 7C were 2,156, 2,157, and 2,158°F. For Test Runs 7A and 7B, the temperature did not vary beyond the range 2,147 to 2,173°F (Figure 35). Test Run 7C showed more temperature variation starting high, about 2,172°F, and reaching as low as 2,115°F before the end of the run. However, all three test runs had the secondary combustion outlet gas temperature above the planned cutoff value of 2,100°F (Table 6). The gas pressure remained negative at all times during the test runs (Figure 36), as required (Table 6).

The monitored stack oxygen concentration averages for the three test runs were 5.82, 5.68, and 5.61 percent. The lowest oxygen concentration of 4.9 percent occurred at the beginning of Test Run 7C (Figure 37), which was well above the planned cutoff value of 3 percent (Table 6). The monitored stack carbon dioxide concentration averages were 5.82, 5.68, and 5.61 percent, respectively; whereas, the carbon monoxide concentrations were 3.66, 3.86, and 0.52 ppm, respectively. The data plots for CO₂ and CO concentrations are shown in Figures 38 and 39, respectively.

Using the monitored CO₂ and CO concentration data, the combustion efficiency for the incinerator process was calculated according to the expression shown in Table 7. For the three test runs, the average combustion efficiency was 99.9955, 99.9952, and 99.9994 percent. Figure 40 shows plots of the calculated data throughout the three test runs. Test Runs 7A and 7B showed similar combustion efficiency ranges being between 99.9946 and 99.9962 percent. Slightly better combustion efficiency was achieved during Test Run 7C ranging between 99.9988 and 99.9999 percent. This was due to very low values (1 percent) of CO present in the stack. In all cases, the incinerator process combustion efficiency was well above the permit cutoff limit of 99.0 percent.

Kiln Outlet Gas Temperatures

RUN 7A

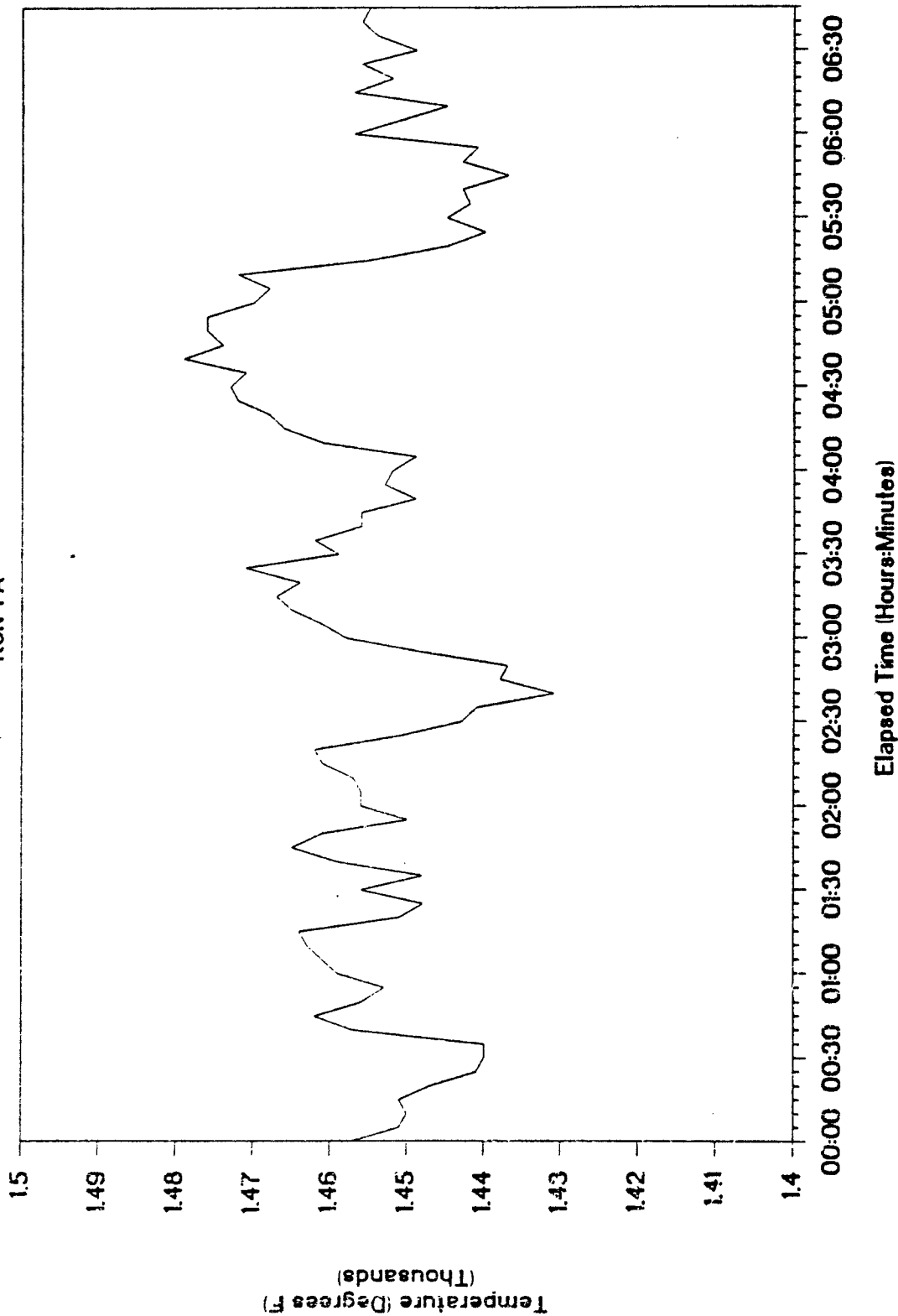


Figure 33. Kiln outlet gas temperatures.

Kiln Outlet Gas Temperatures

RUN 7B

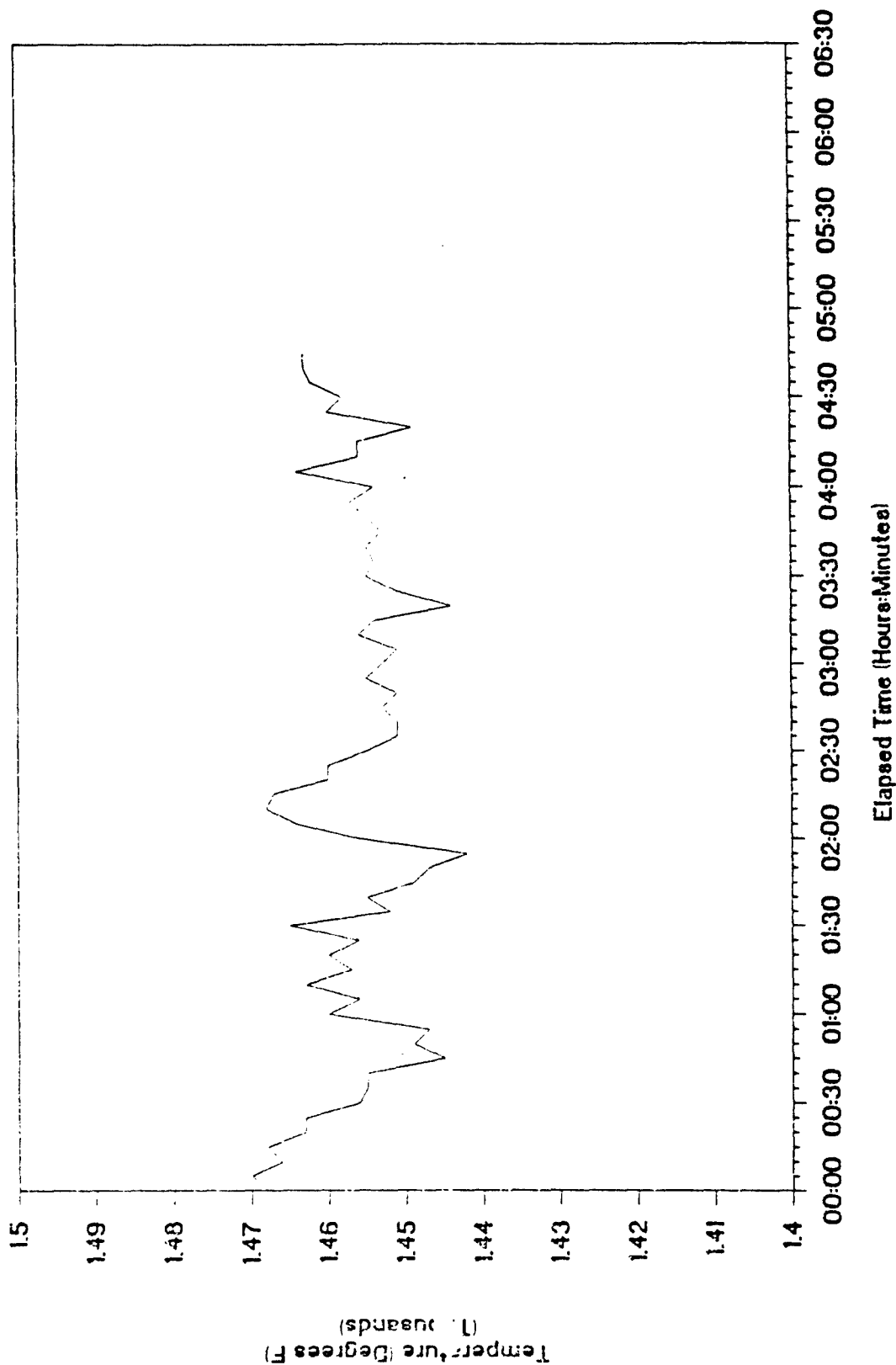


Figure 33. Kiln outlet gas temperatures (continued).

Kiln Outlet Gas Temperatures

RUN 7C

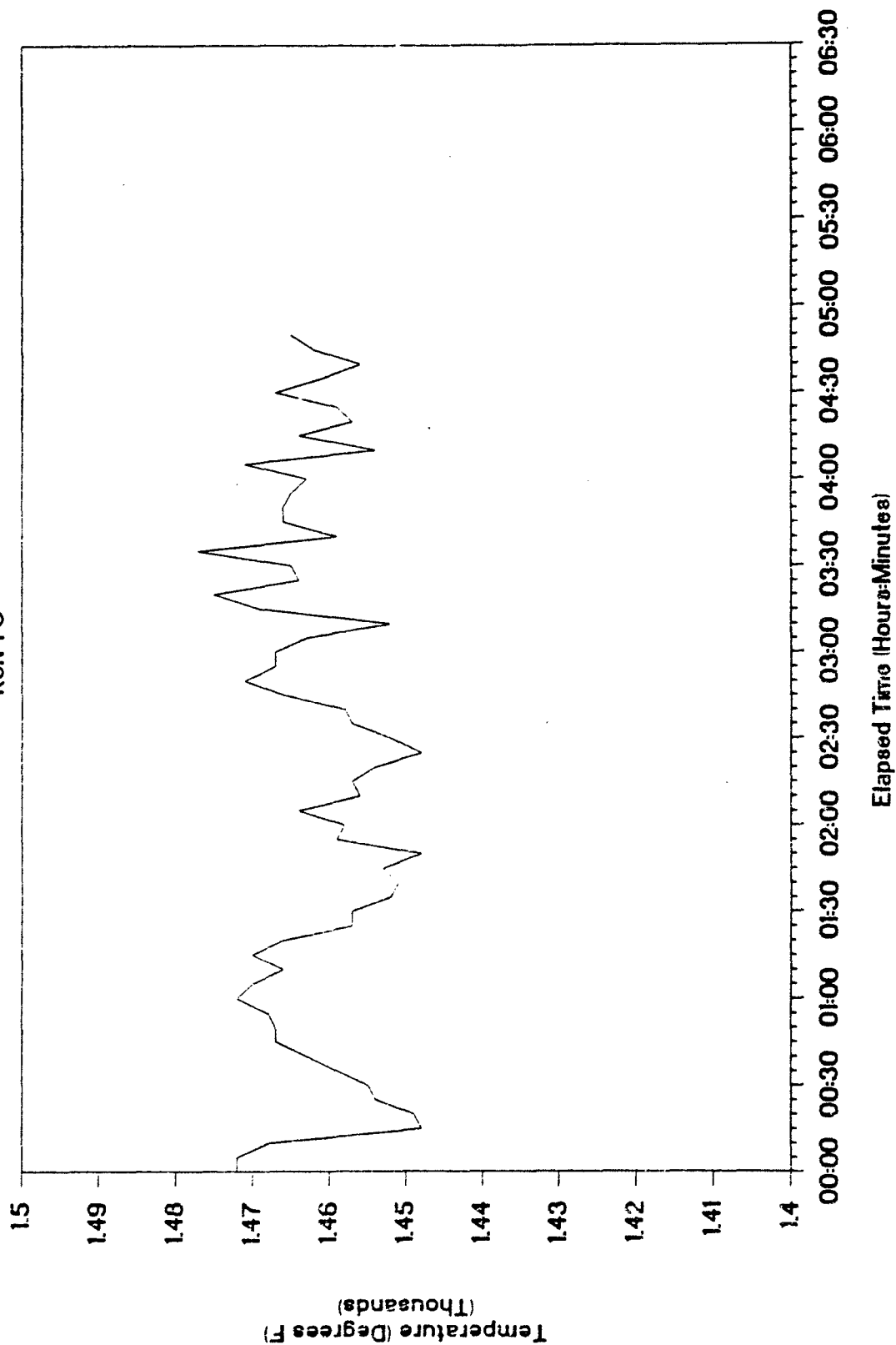


Figure 33. Kiln outlet gas temperatures (concluded).

Kiln Outlet Gas Pressure

Run 7A

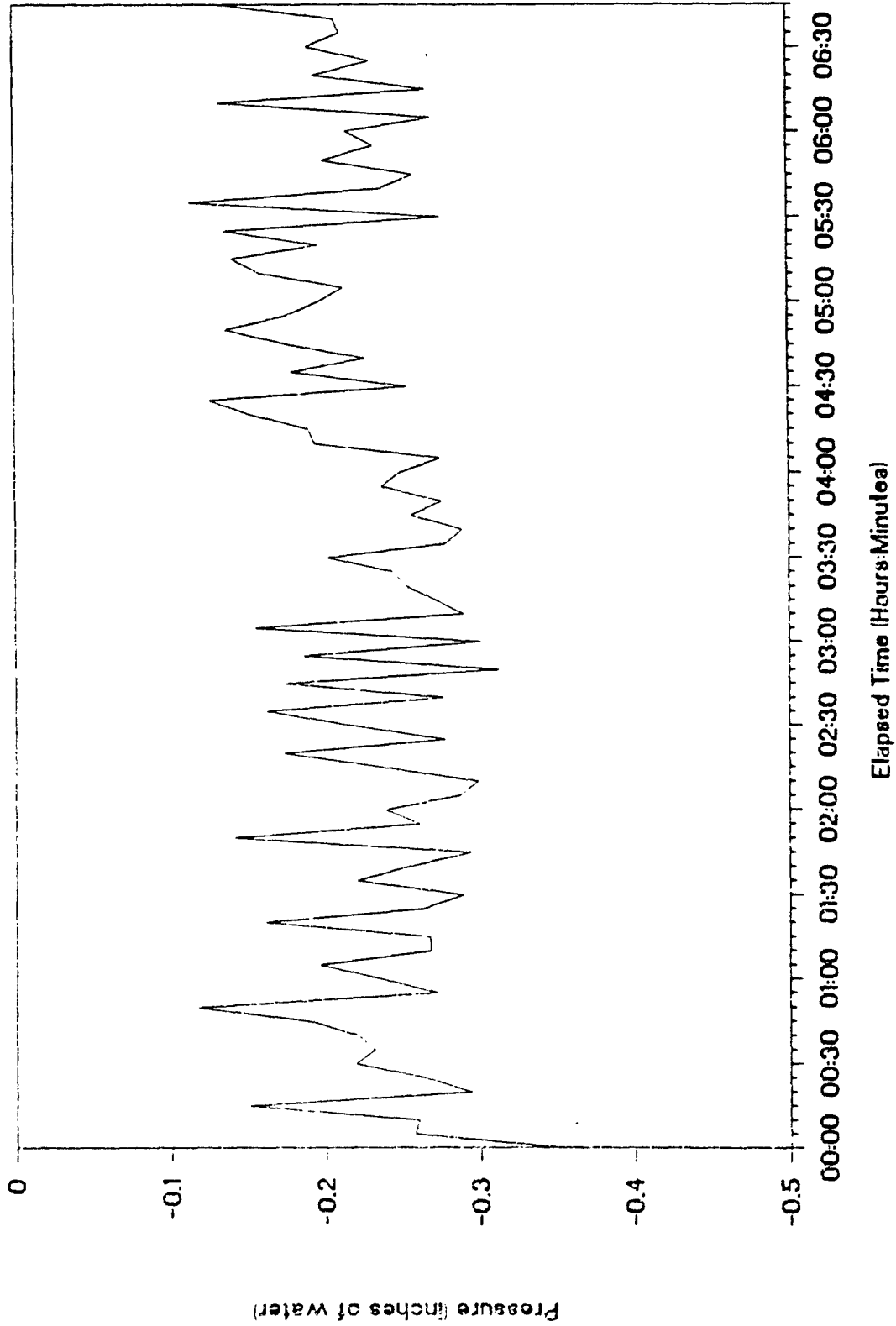


Figure 34. Kiln outlet gas pressure during NCBC trial burn tests.

Kiln Outlet Gas Pressure

Run 7B

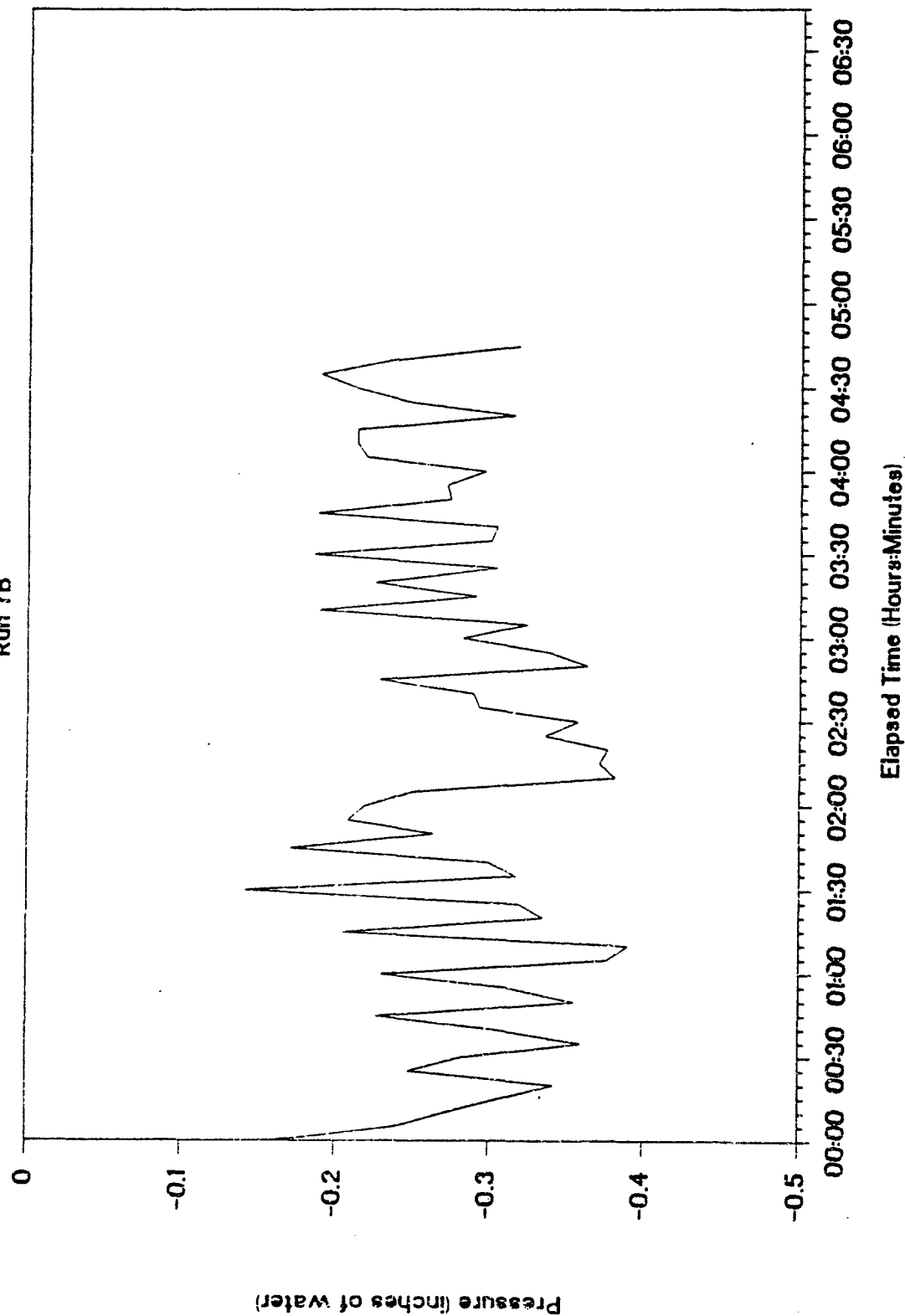


Figure 34. Kiln outlet gas pressure during NCBC trial burn tests (continued).

Kiln Outlet Gas Pressure

Run 7C

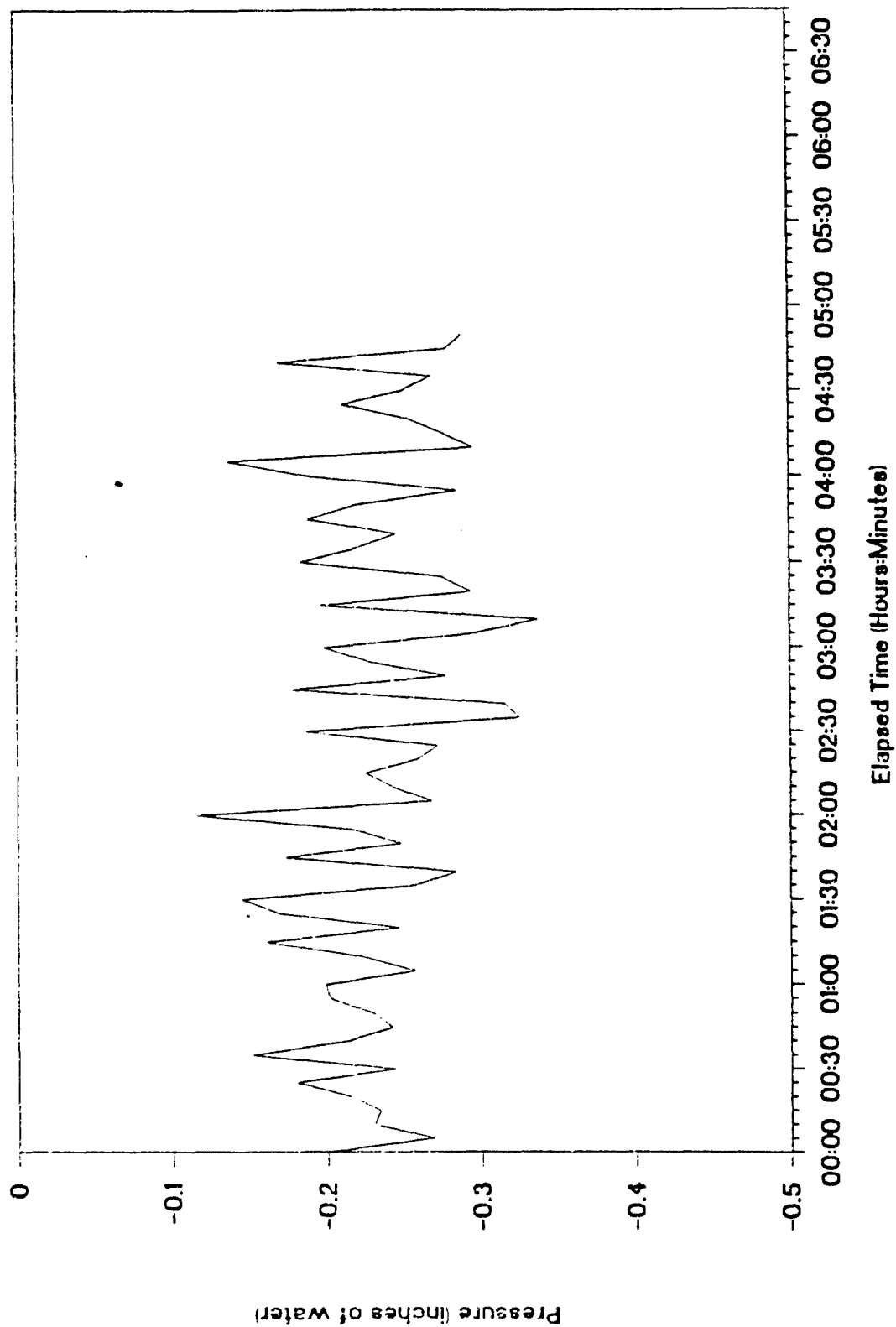


Figure 34. Kiln outlet gas pressure during NCBC trial burn tests (concluded).

Secondary Combustor Outlet Gas Temperature

Run 7C

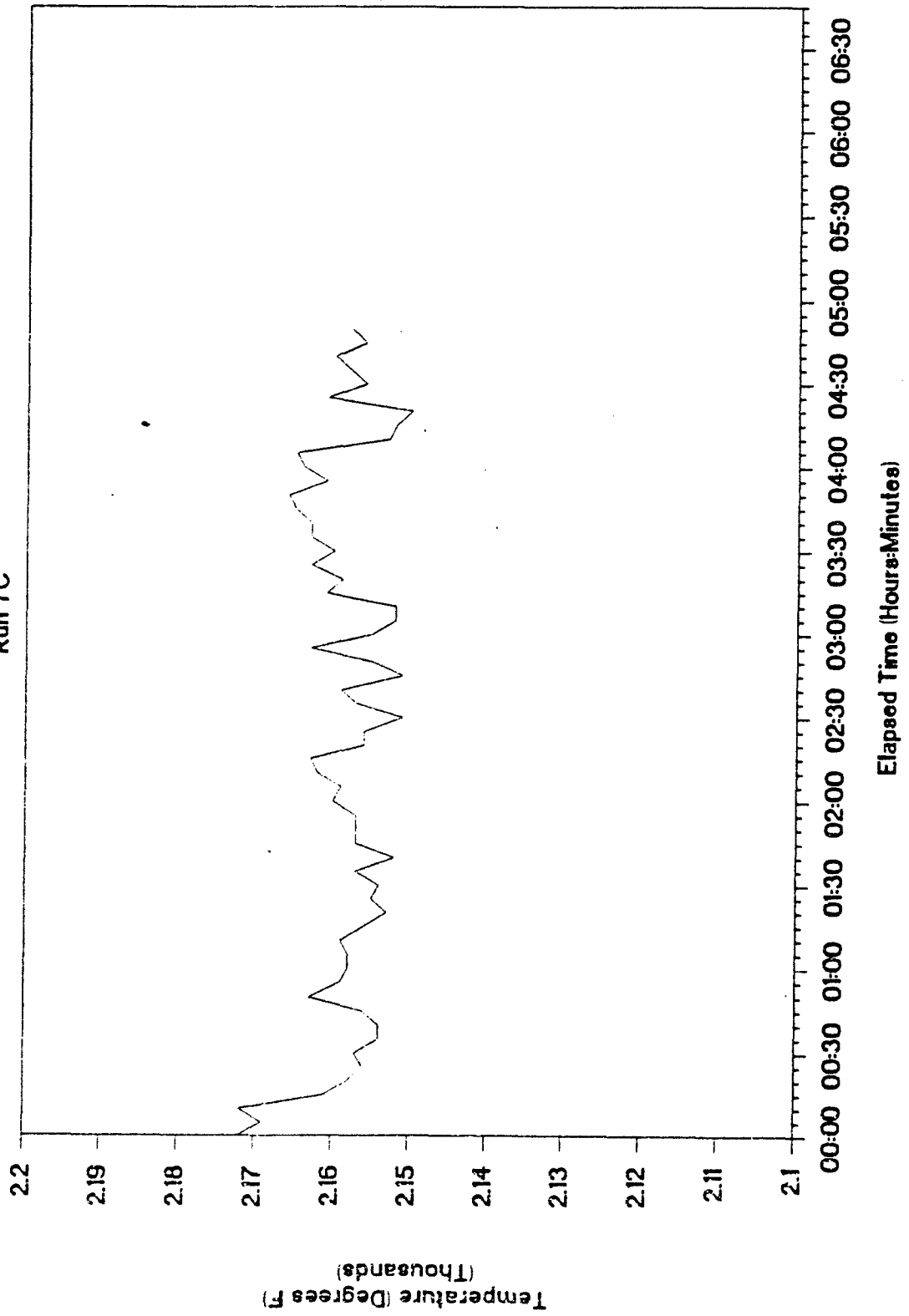


Figure 35. Secondary combustor outlet gas temperature during NCBC trial burn tests.

SCC Outlet Gas Temperature

Run 7B

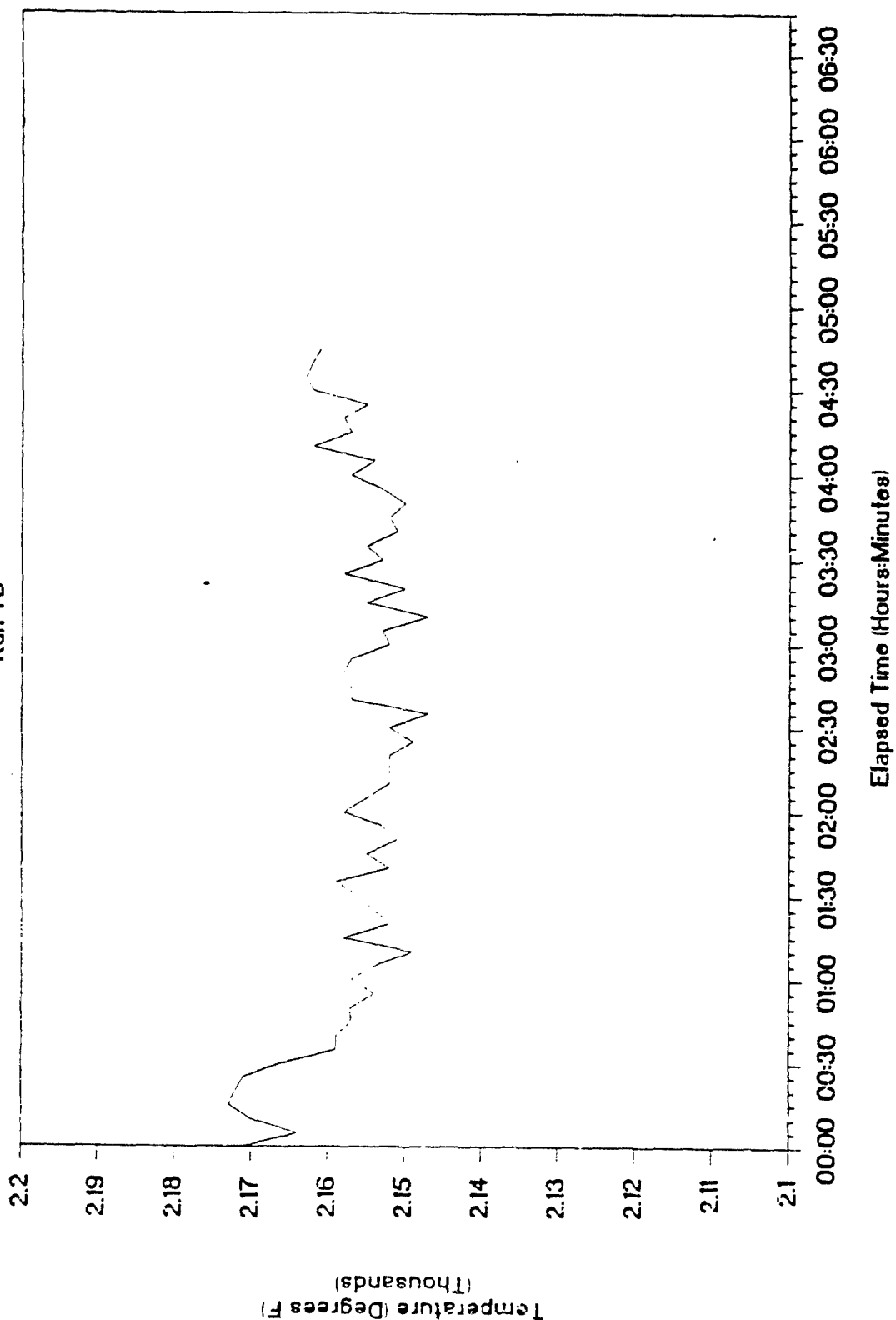
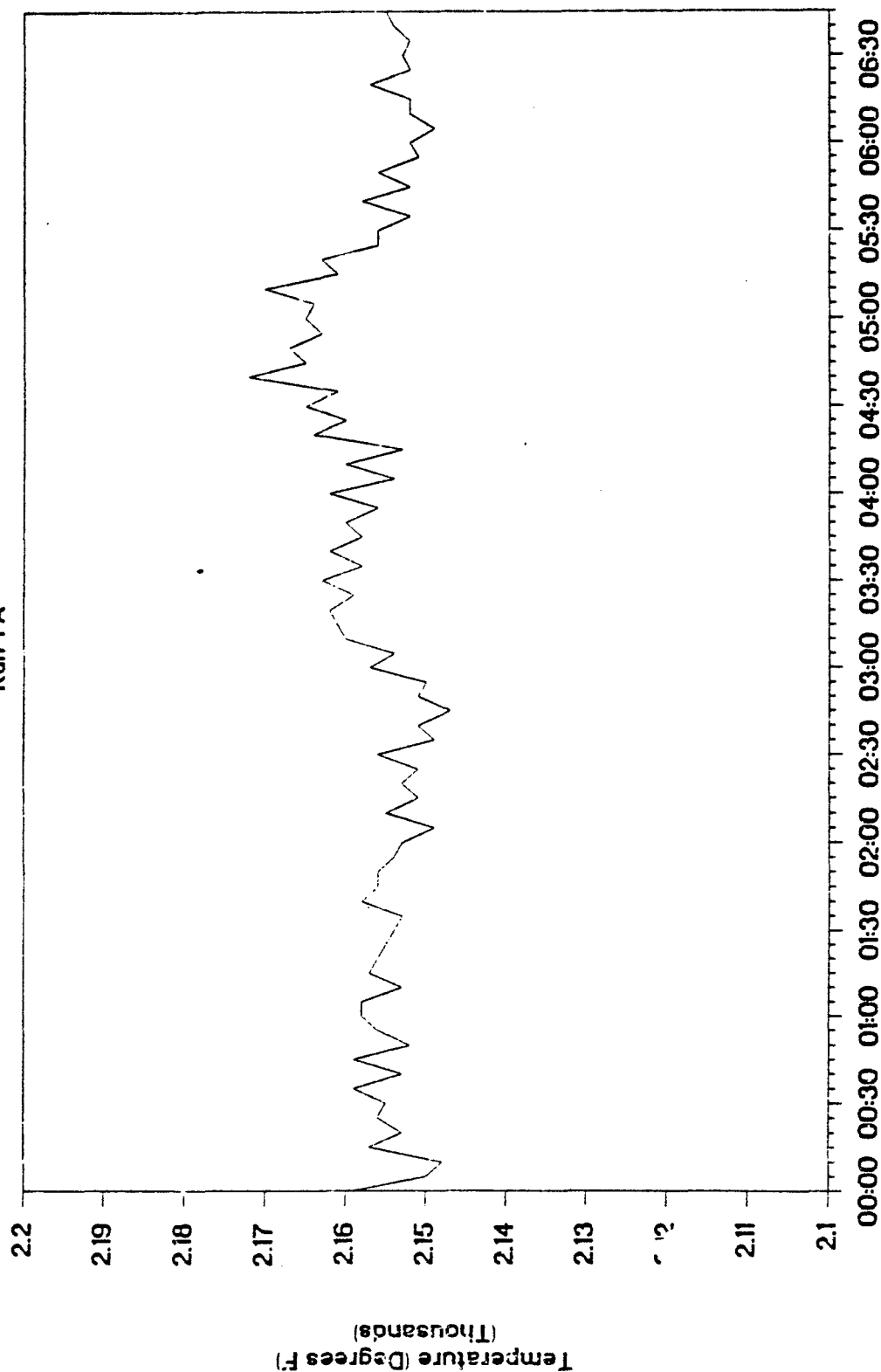


Figure 35. Secondary combustor outlet gas temperature during NCBC trial burn tests (continued).

SCC Outlet Gas Temperature

Run 7A



Elapsed Time (Hours:Minutes)

Figure 35. Secondary combustor outlet gas temperature during NCBC trial burn tests (concluded).

Run 7A



Figure 36. Secondary combustor outlet gas pressure during NCBC trial burn tests.

SCC Outlet Gas Pressure

Run 7 B

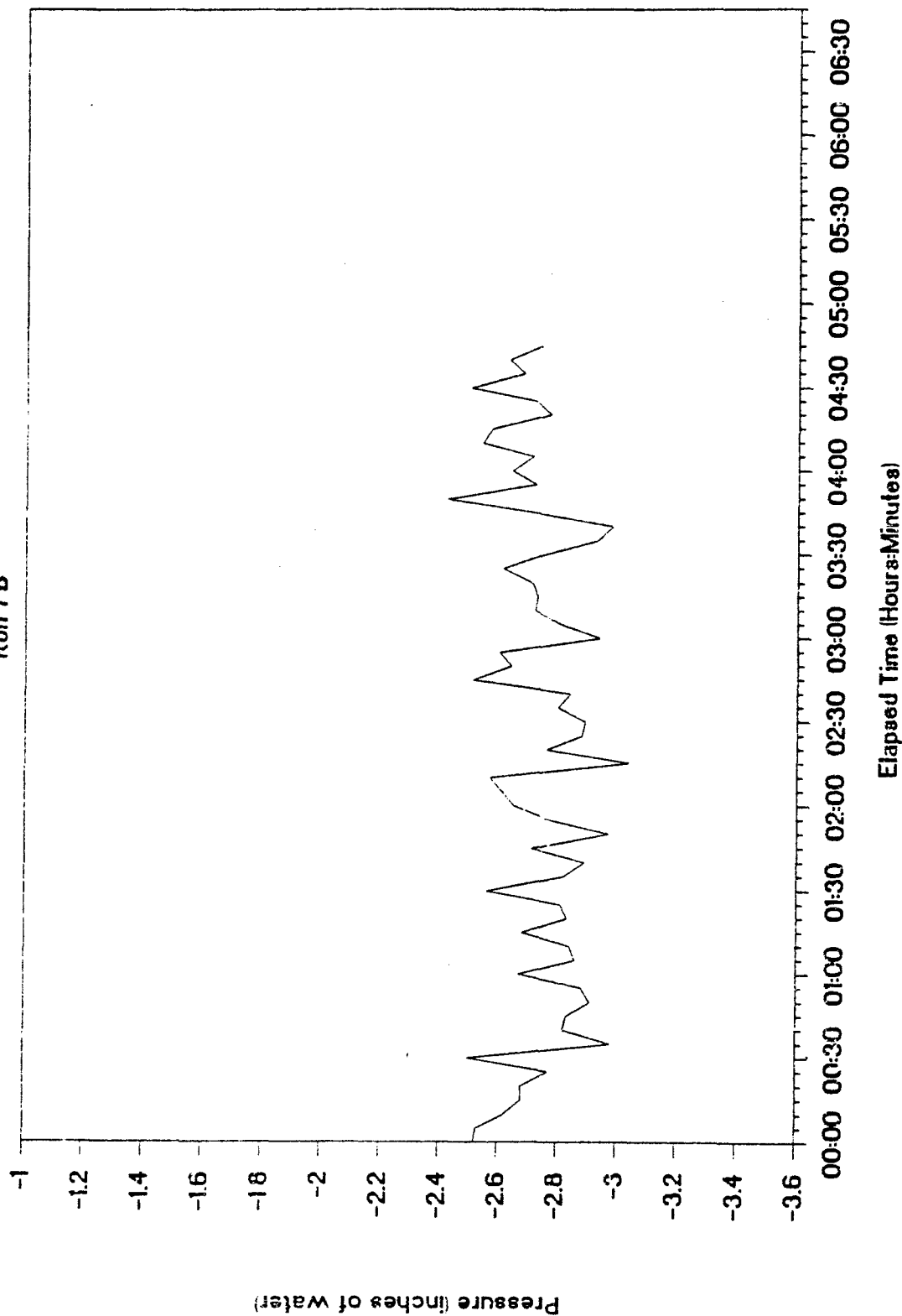


Figure 36. Secondary combustor outlet gas pressure during NCBC trial burn tests (continued).

SCC Outlet Gas Pressure

Run 7C

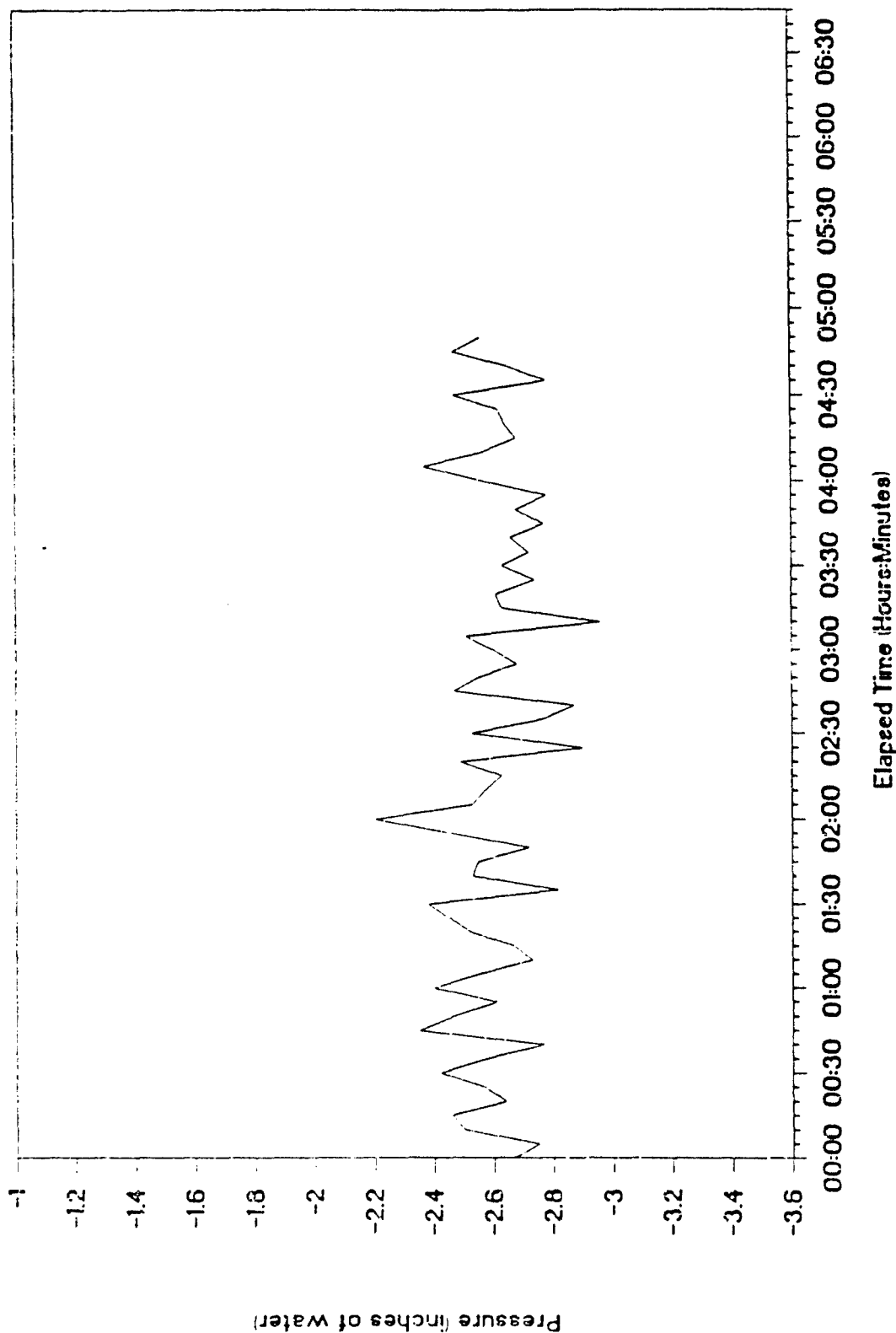


Figure 36. Secondary combustor outlet gas pressure during NCBC trial burn tests (concluded).

Stack Outlet Oxygen

Run 7A

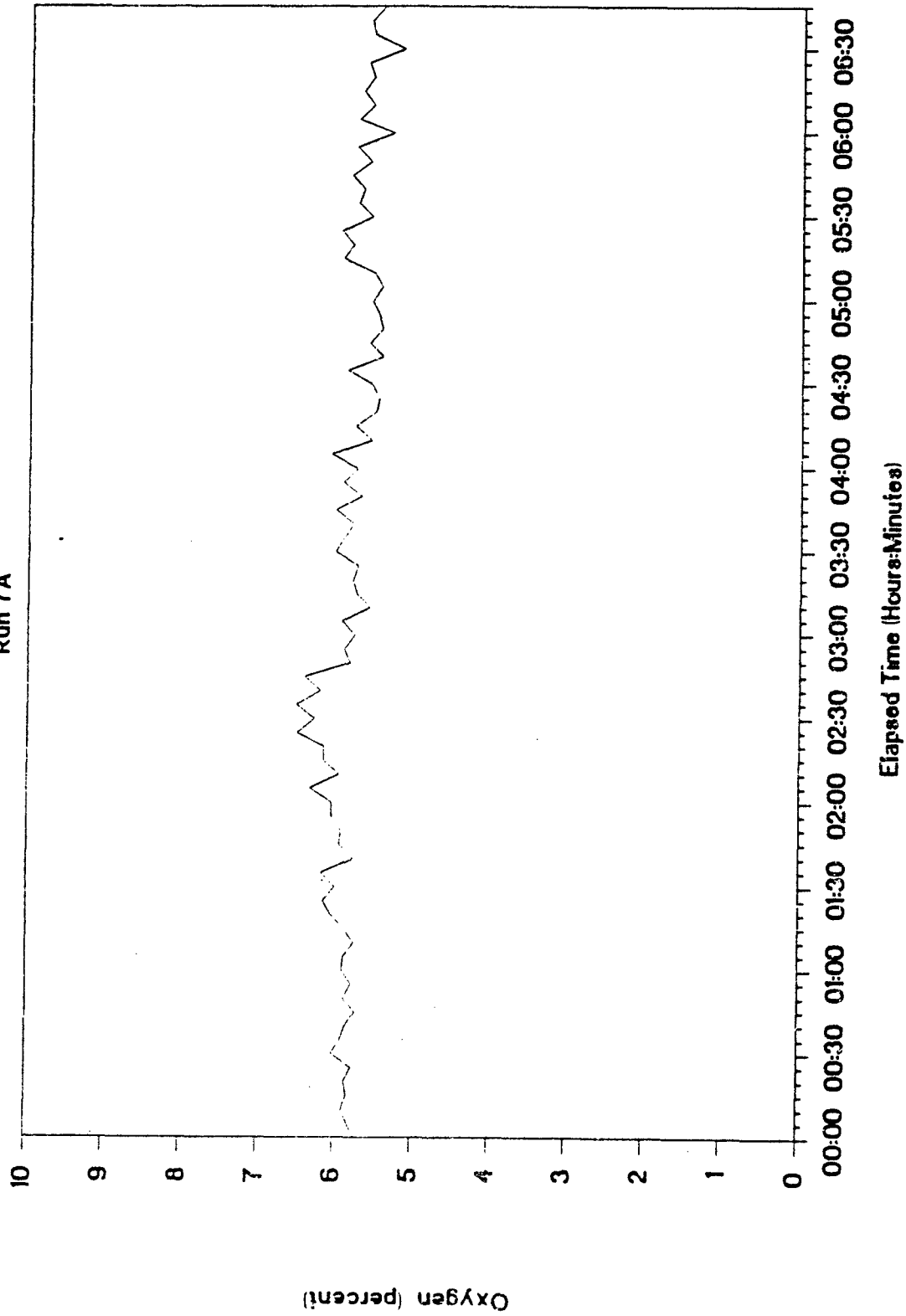


Figure 37. Monitored stack oxygen concentrations during NCBC trial burn tests.

Stack Outlet Oxygen

Run 7B

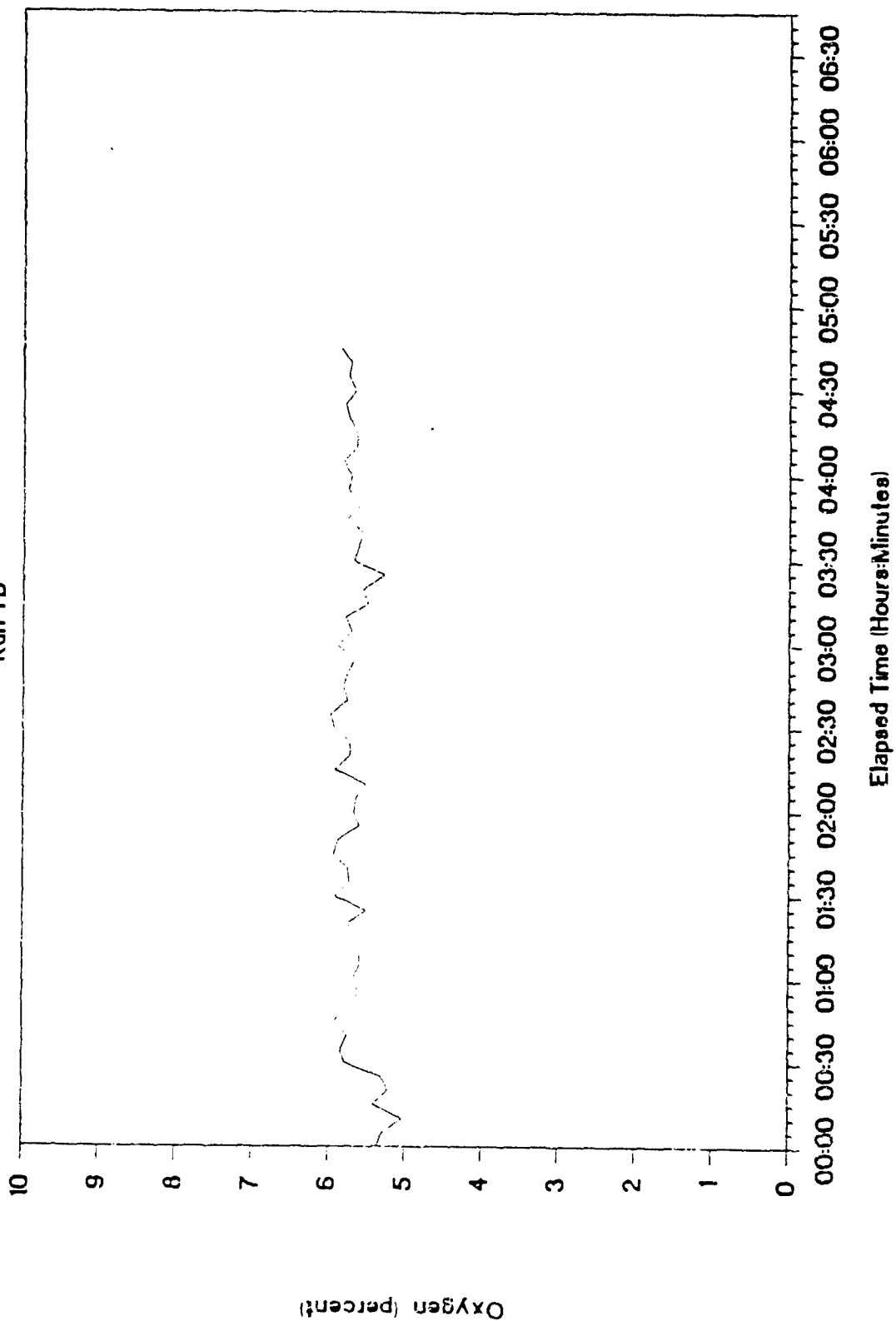
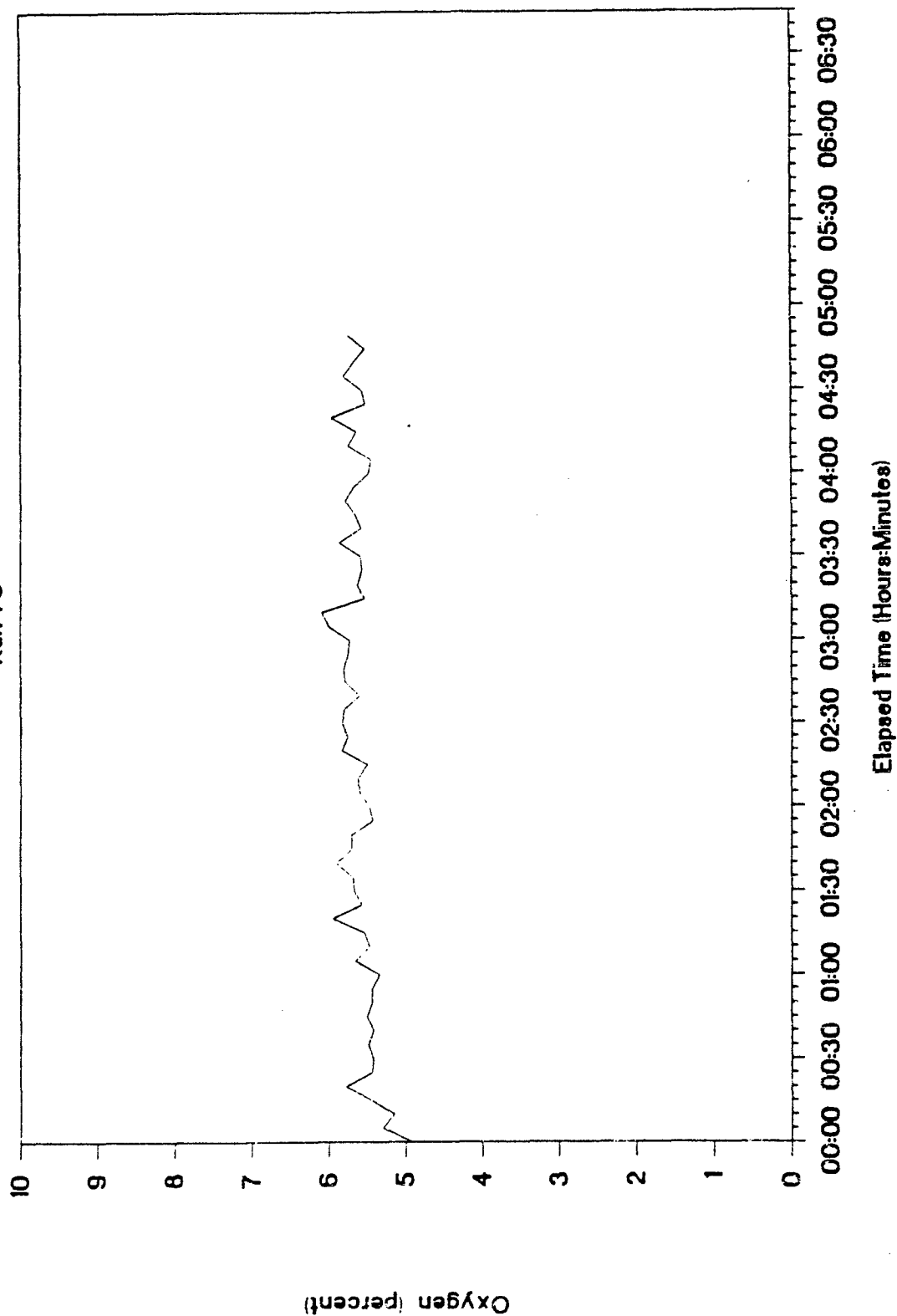


Figure 37. Monitored stack oxygen concentrations during NCBC trial burn tests (continued).

Stack Outlet Oxygen

Run 7C



Elapsed Time (Hours:Minutes)

Figure 37. Monitored stack oxygen concentrations during NCBC trial burn tests (concluded).

Stack Outlet Carbon Dioxide

Run 7A

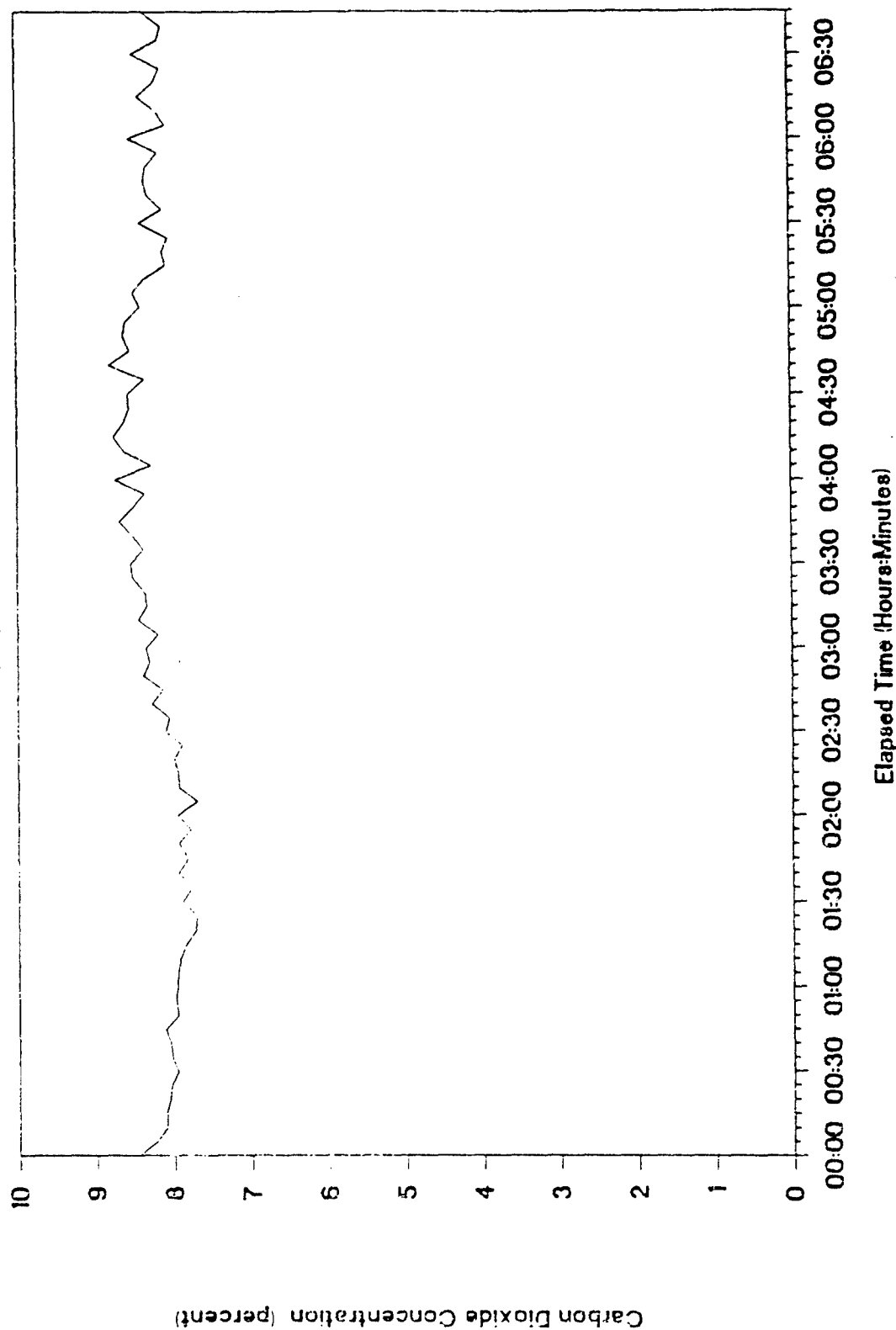


Figure 38. Monitored stack carbon dioxide concentrations during NCBC trial burn tests.

Stack Outlet Carbon Dioxide

Run 7B

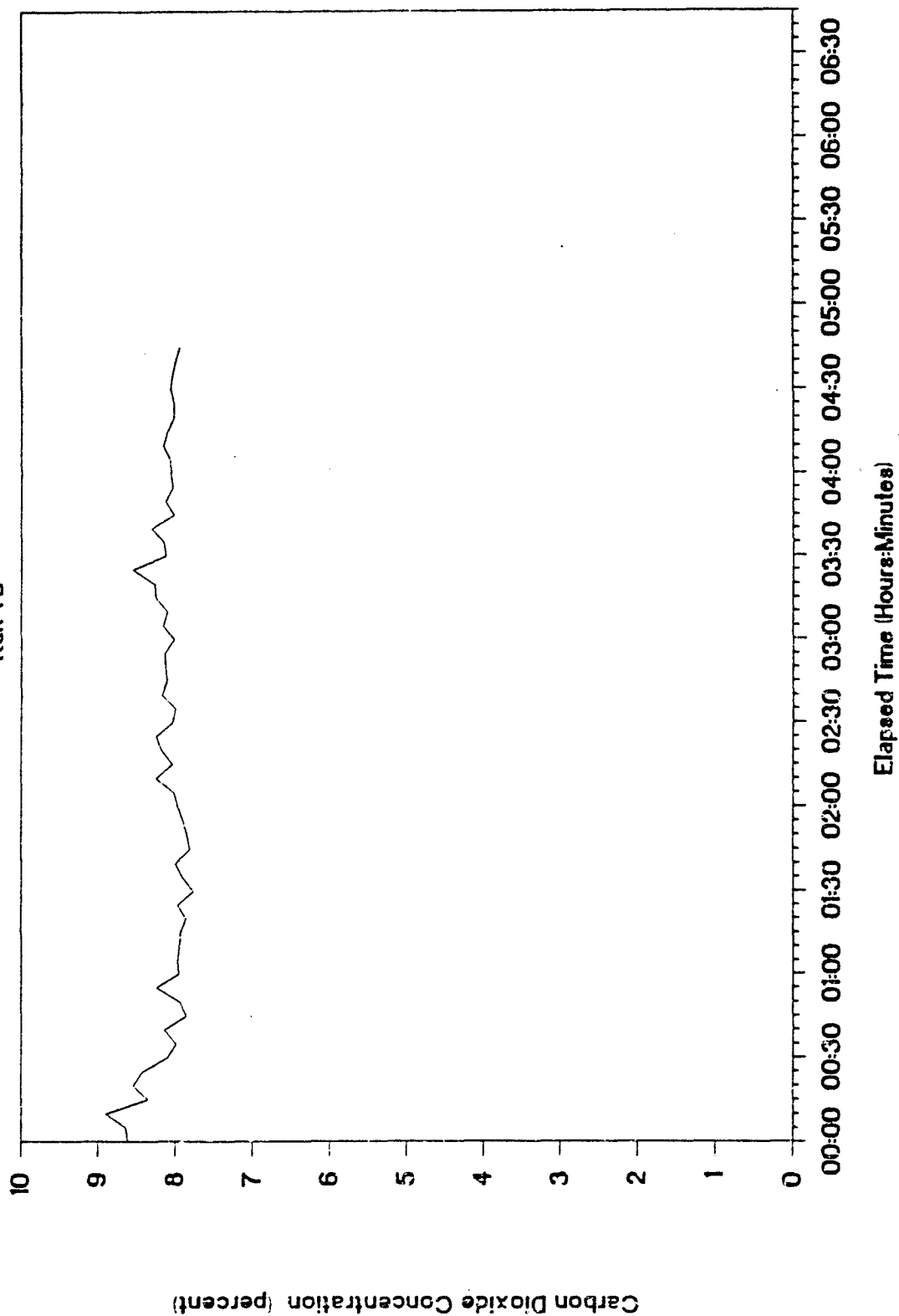


Figure 38. Monitored stack carbon dioxide concentrations during NCBC trial burn tests (continued).

Stack Outlet Carbon Dioxide

Run 7C

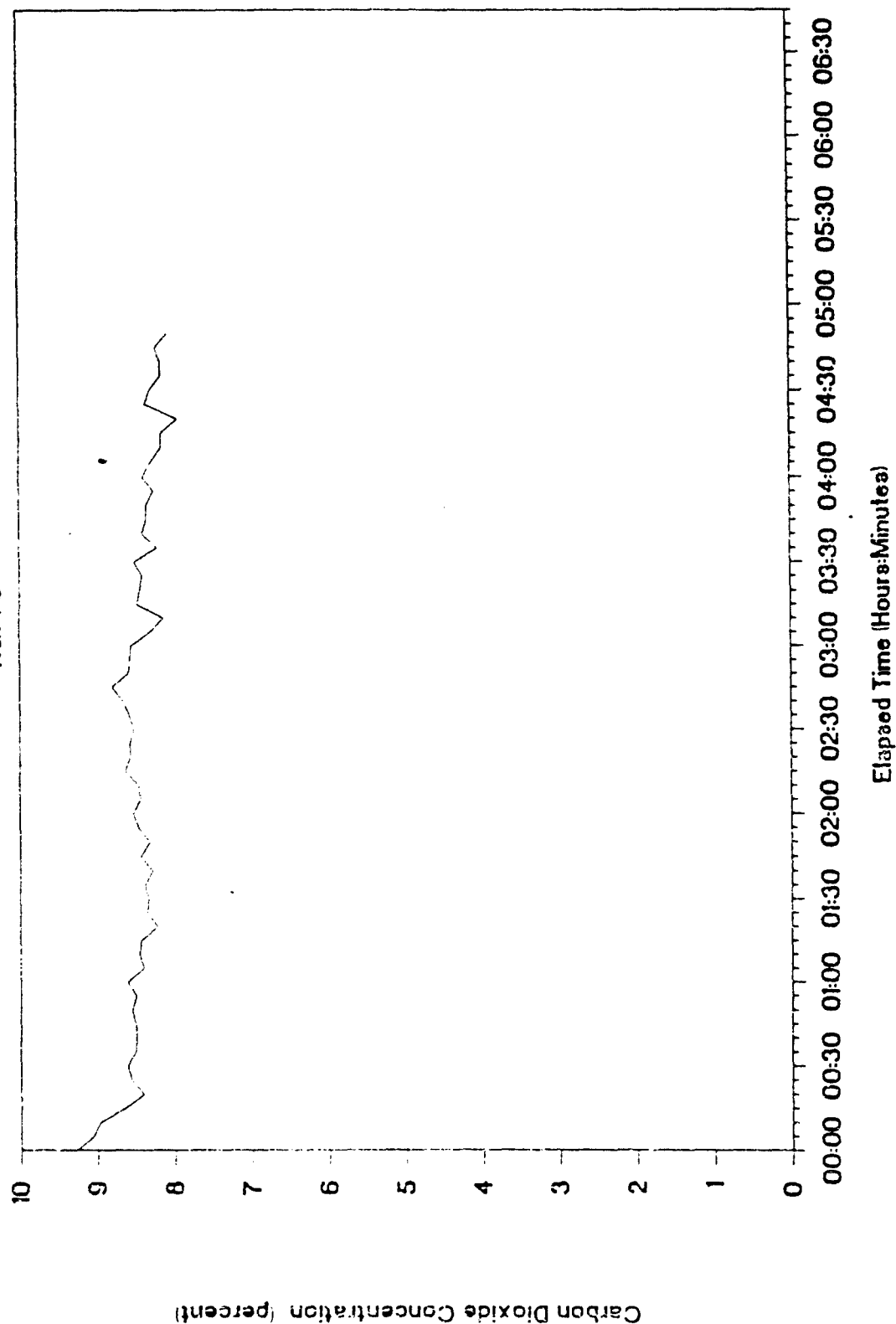


Figure 38. Monitored stack carbon dioxide concentrations during NCBC trial burn tests (concluded).

Stack Outlet Carbon Monoxide

Run 7A

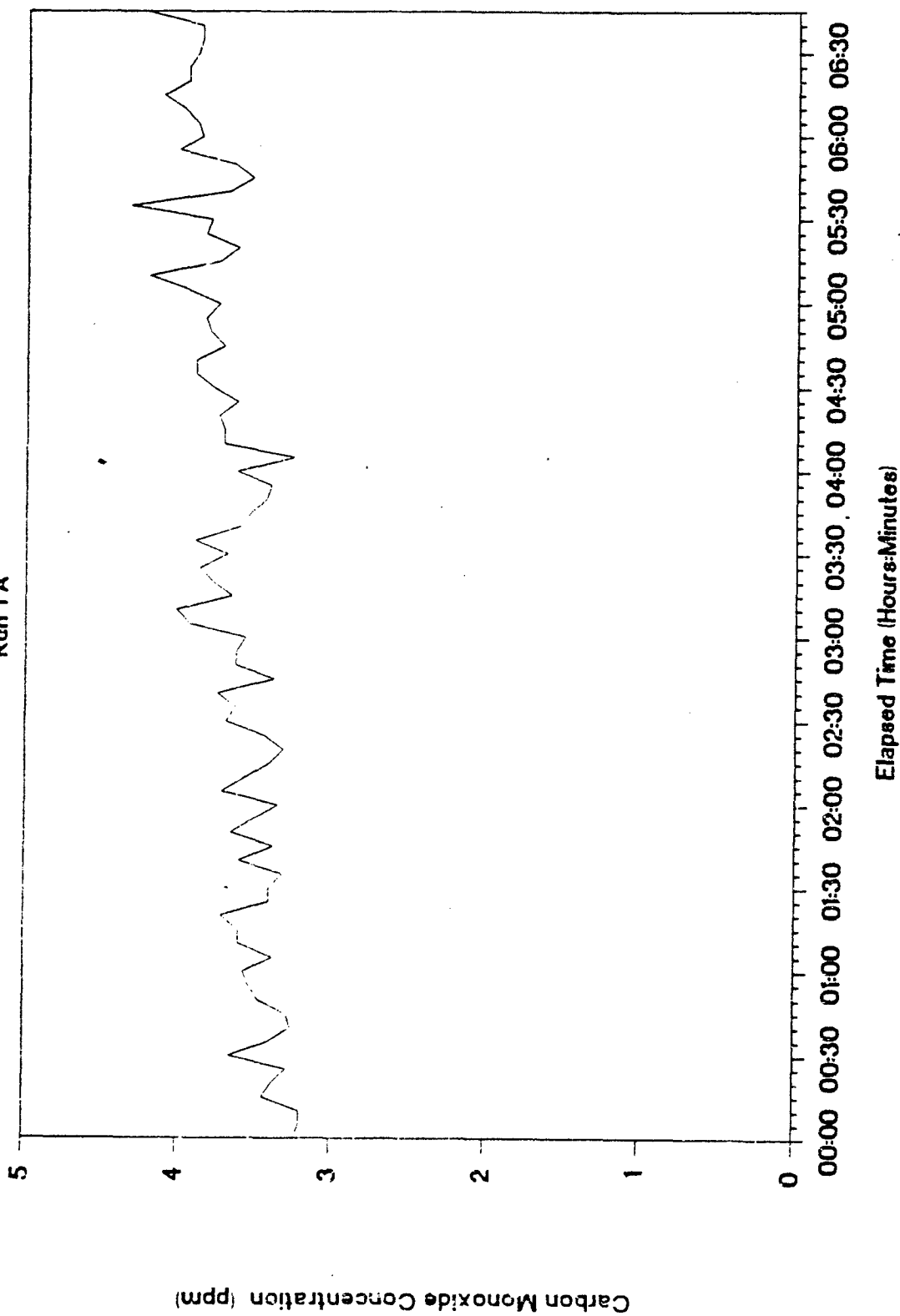


Figure 39. Monitored stack carbon monoxide concentrations during NCRC trial burn tests.

Stack Outlet Carbon Monoxide

Run 7B

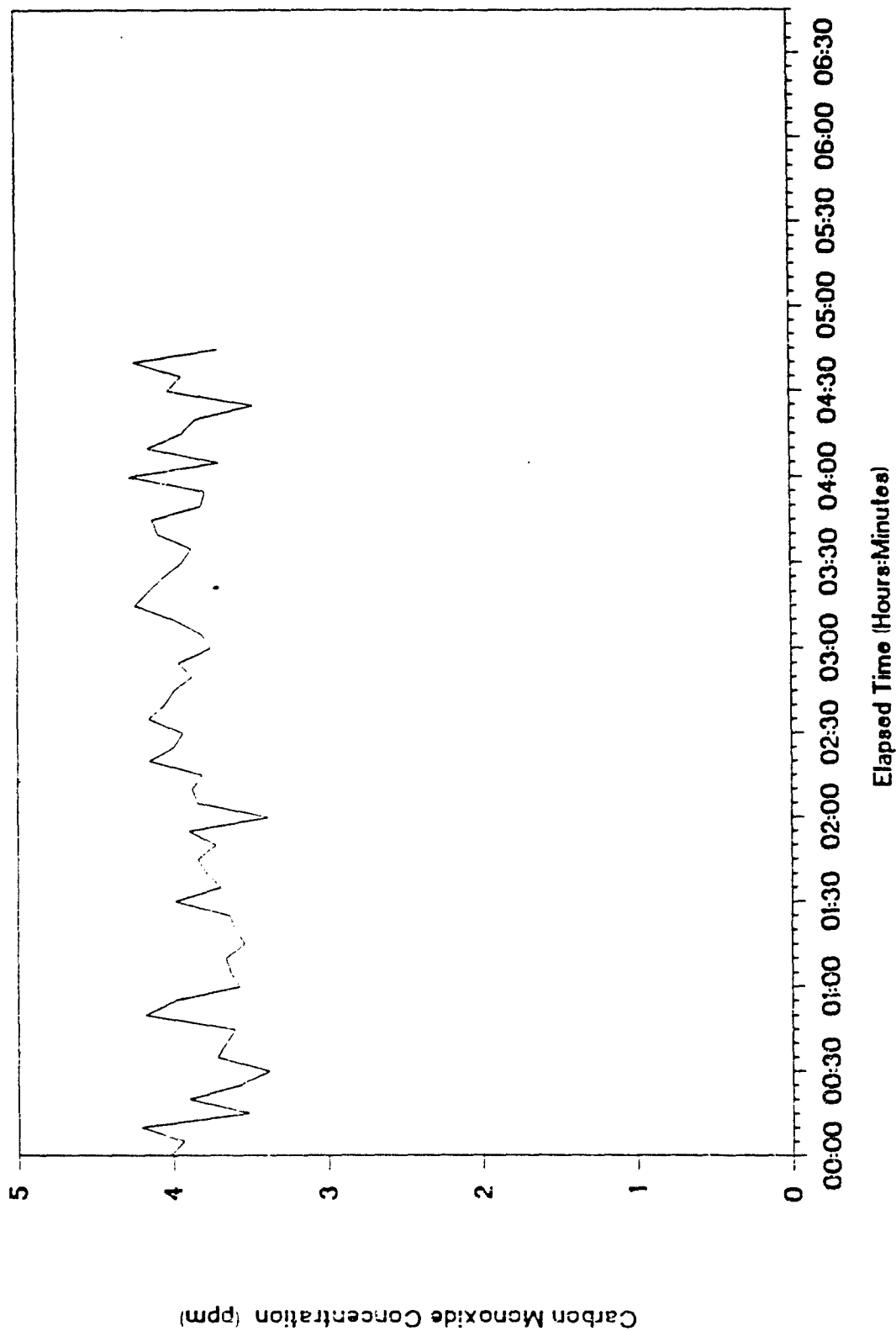


Figure 39. Monitored stack carbon monoxide concentrations during NCBC trial burn tests (continued).

Stack Outlet Carbon Monoxide

Run 7C

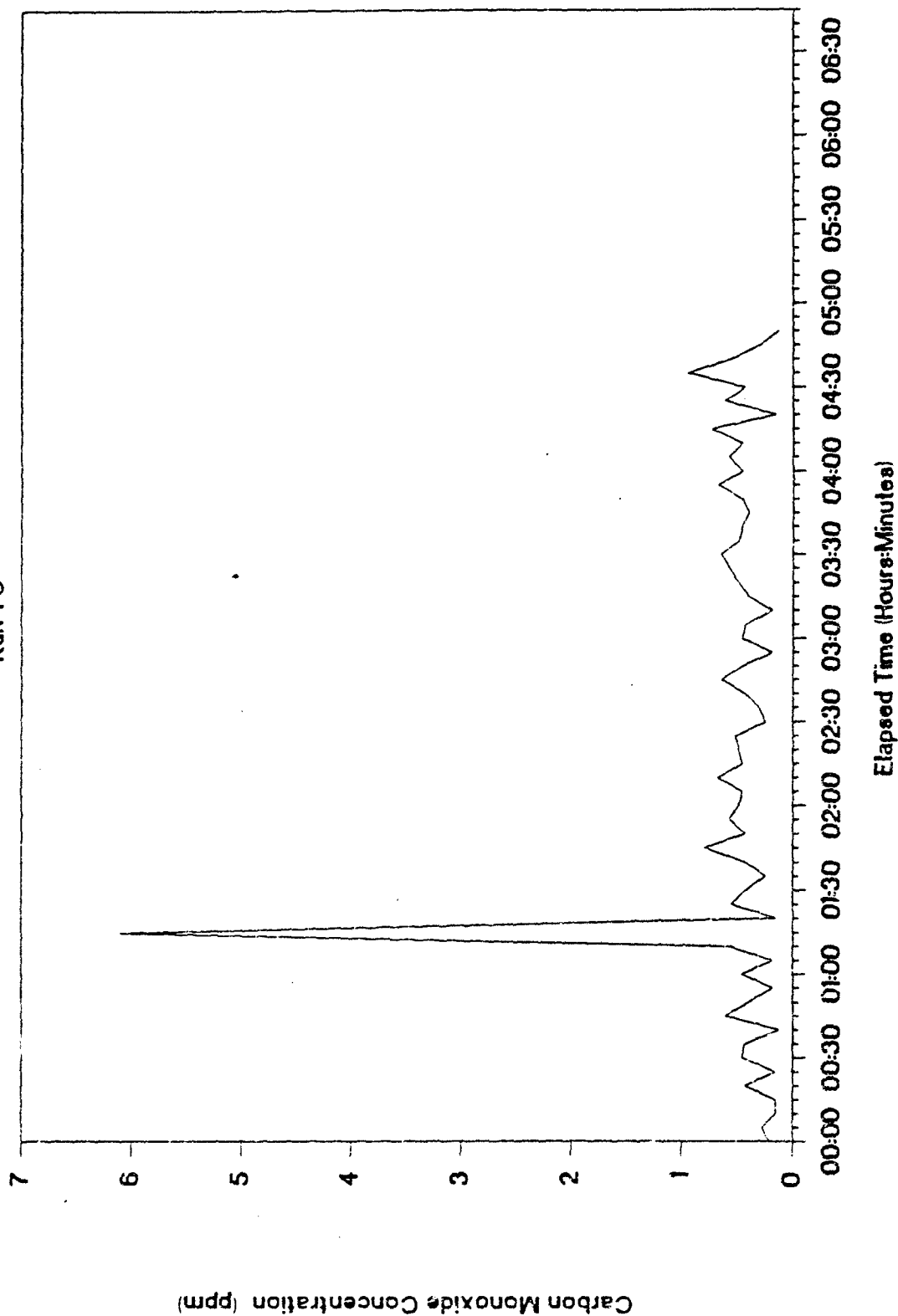


Figure 39. Monitored stack carbon monoxide concentrations during NCBC trial burn tests (concluded).

COMBUSTION EFFICIENCY

Run 7A

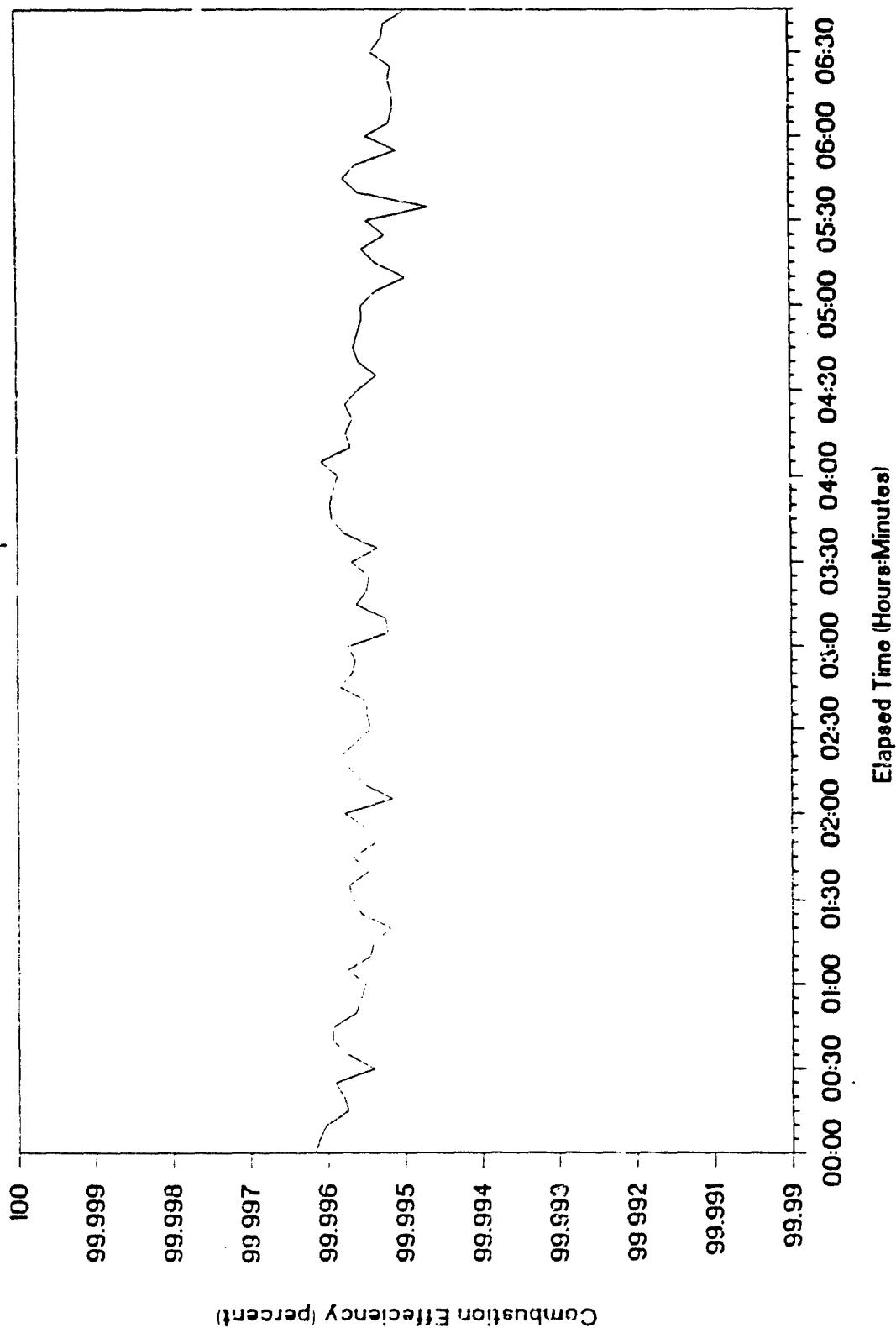


Figure 40. Calculated combustion efficiency for incinerator trial burn tests at NCBC.

----- Run 7B -----

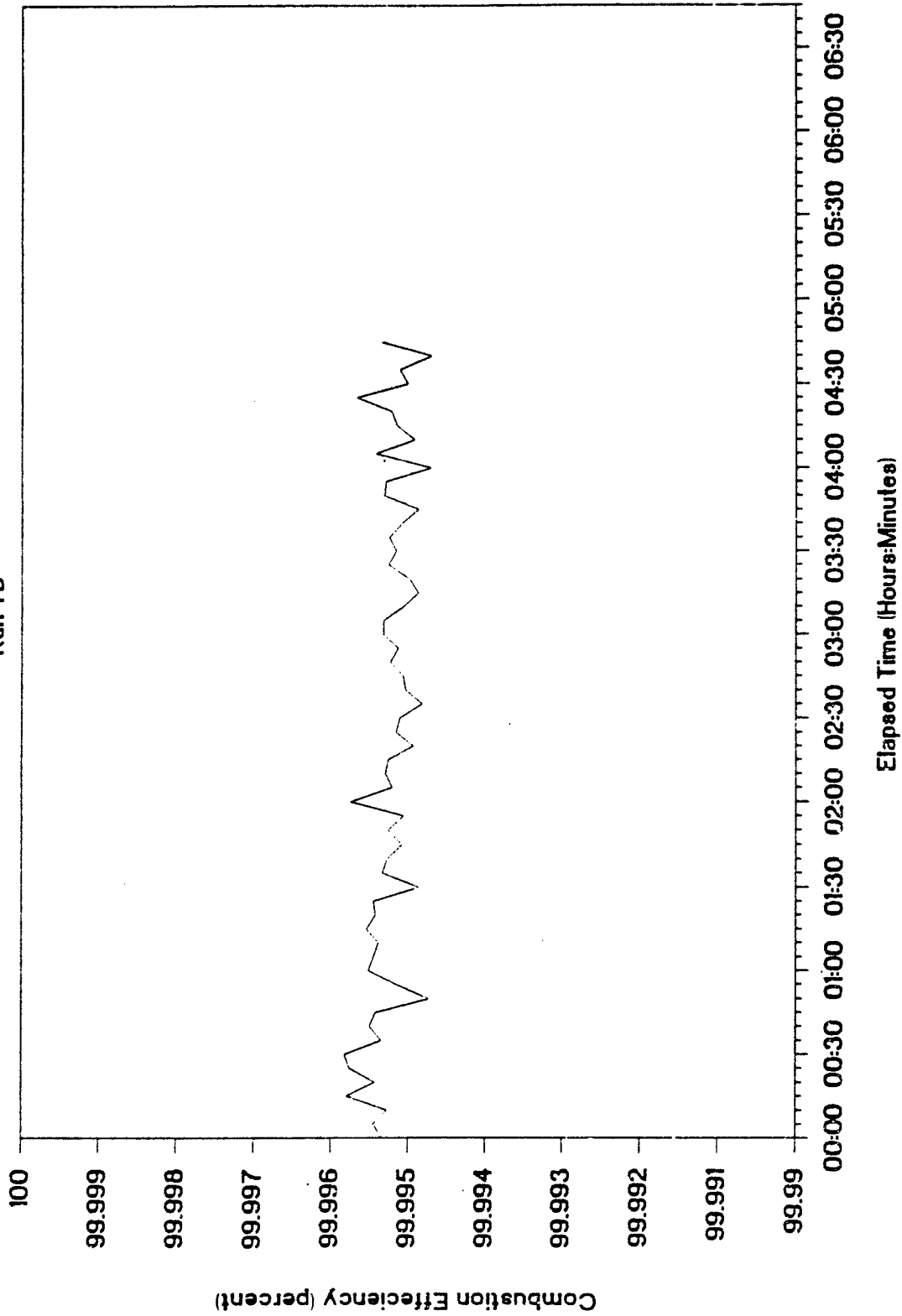


Figure 40. Calculated combustion efficiency for incinerator trial burn tests at NCBC (continued).

COMBUSTION EFFICIENCY

Run 7C

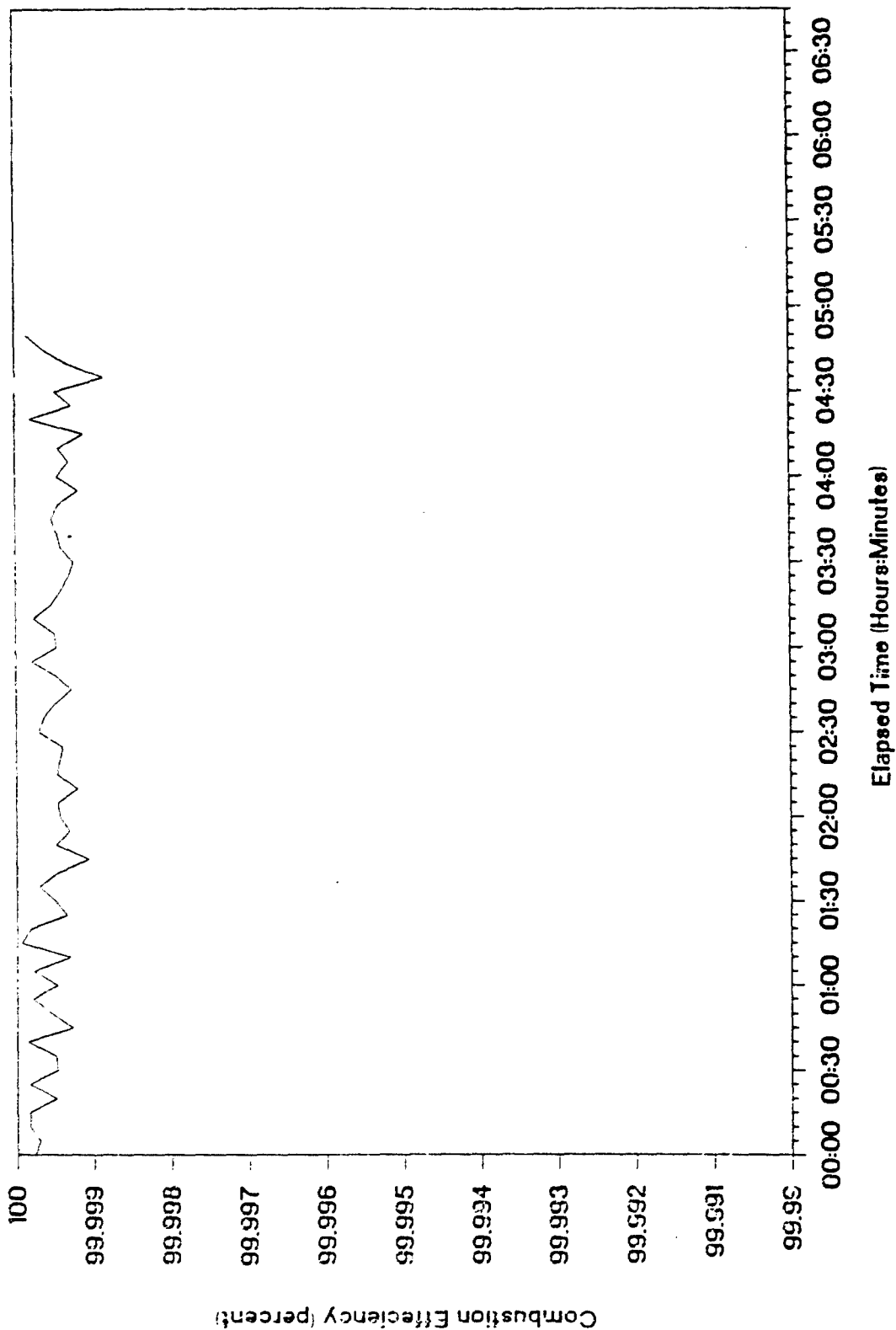


Figure 40. Calculated combustion efficiency for incinerator trial burn tests at NCBC (concluded).

For more detailed operating parameter tabulated data, see Appendix D. Compliance with DRE, chlorine emissions, and particulate emissions permit requirements is discussed in Section VI.

4. Health and Safety Monitoring Results

Protective clothing and respirator requirements stated in Section III.D.1.a. were followed at the beginning of the trial burn activities. The Level A personnel protection requirement for POHC handlers was reduced to Level B protection after the 1,2,4-TCB liquid transfer valving and procedures from the drums were developed, such that the splashing hazard on personnel was determined by the hygienist to be acceptably small. This change permitted use of poly-coated Tyvek^R suits in place of the encapsulated suits, which are more difficult to work in. The SCBA respirator was still used by the POHC handlers.

Monitoring for ambient concentrations of the surrogate compounds, dust, and heat stress was performed daily by the site health and safety industrial hygienist. Results are summarized in Table 9.

a. POHC Ambient Air Monitoring

The POHC ambient air monitoring consisted of direct reading measurements with a TIP photoionization detector and operation of air sampler pumps with charcoal tubes installed. Calibration of the TIP monitors was performed according to supplier instructions. Measurements were taken by the hygienist, according to areas where ambient concentrations of the POHC were suspected to be associated with site operations. The POHC mixing area was excluded from this monitoring because of suspected high concentrations that would be separately monitored by air sampling. The data reported show ambient concentrations less than 1 ppm were generally the case. The highest reading, near 9 ppm, was noted on May 8 at the feed hopper platform.

TABLE 9. AIR SAMPLER 1,2,4-TCB AND HCE CONCENTRATION RESULTS DURING NCBC TRIAL BURN OPERATIONS

<u>Date</u>	<u>Sampler Location</u>	<u>Sample Number</u>	<u>Concentration^a (mg/m³)</u>	
			<u>TCB</u>	<u>HCE</u>
May 8	Stack platform working area	B01	>0.18	0.73
	Feed hopper platform	B02	0.30	1.82
	POHC mixing tent work area	B03	1,060	14,100
May 9 ^b	Stack platform working area	B04 ^c	--	--
	Feed hopper platform	B05	0.38	>0.09
	POHC mixing tent working area	B06	2.82	16.5
May 10	Stack platform working area	B07	>1.0	>0.1
	Feed hopper platform	B08	>1.0	>0.1
	POHC mixing tent work area	B09	1,855	40,800
May 11	Stack platform working area	B10	>1.09	0.43
	Feed hopper platform	B11	5.6	13.4
	Base of stack	B12	>1.06	1.28
May 12	Feed hopper platform	B13	18.4	125
May 13	Fence line at kiln	B14	1.39	.78
	Feed hopper platform	B15	48.4	23.2
May 14 ^d	Feed hopper platform	B16	2.4	3.6
	Fence line at kiln	B17 ^e	94	455

TABLE 9. AIR SAMPLER 1,2,4-TCB and HCE CONCENTRATION RESULTS DURING NCBC TRIAL BURN OPERATIONS (CONCLUDED)

<u>Date</u>	<u>Sampler Location</u>	<u>Sample Number</u>	<u>Concentration^a</u> <u>(mg/m³)</u>	
			<u>TCB</u>	<u>HCE</u>
May 16	Fence line at kiln	B18 ^f	--	--
	Feed hopper platform	B19 ^f	--	--

a. Laboratory analysis of the filter samples was performed by West-Paine Laboratories of Baton Rouge, Louisiana. The charcoal tubes front and back sections were desorbed with 2 mL of 5 percent carbon disulfide and 50 percent methylene chloride mixture, placed on a continuous shaker for 60 minutes and exchanged to hexane. The samples were then analyzed by gas chromatographic methods in accordance with EPA Method 8120, Chlorinated Hydrocarbons (Reference 19). See Appendix N for sampler and analytical data supporting these calculational results.

b. Blank showed the following analytical results: TCB, <0.1 lg; HCE, <0.05 lg.

c. Sample was mishandled after sample run; results are void.

d. Blank taken on this date showed the following analytical results: TCB, <0.50 lg; HCE, 0.09 lg (where detection limit was 0.05 lg).

e. Pump malfunctioned after 212 minutes of sample run.

f. Sampler equipment malfunctioned, voiding a valid sample.

The air sampling was performed at selected site locations as listed in Table 9. Sampling generally occurred over a 4-hour duration. The POHC concentrations were clearly highest in the POHC mixing tent working area. The HCE concentration was the higher of the two compounds, with the highest result being 40.8 mg/m³. The highest 1,2,4-TCB concentration was found to be 1.9 mg/m³. Both results are less than the limits for these compounds discussed in Section III.D.1.a.

b. Dust Monitoring

Daily direct reading monitor measurements showed dust concentrations in the range 0 to 0.02 mg/m³, which is comparable to the dust concentrations that were measured during the verification test burns (Reference 1). Because dust-producing activities were minor, the measurements are considered to represent general background conditions.

c. Heat Stress

The WBGT heat stress monitor was used to determine whether conditions warranted any reduction in permitted activities. Measurements on April 30 and May 1, when temperatures were in the low 80-degree range, showed WBGT readings of 27.3 and 27.4°C, respectively. For continuous heavy work, the limit is 25°C WBGT (Reference 25). On these days the hygienist imposed a 25-percent rest period each hour, which was consistent with a moderate workload (26.7 to 28.0°C WBGT, Reference 25). On other days during the trial burn activities, the temperatures were sufficiently low to not require any restriction.

d. Skin Irritation Incident

One personnel incident was reported and investigated. On May 13, the worker pitching the POHC containers into the feed hopper

experienced a hot burning sensation on the left side of his face and neck. He was quickly relieved and rushed to an emergency shower for cleaning. It was determined that the area of irritation showed signs of mild sunburn. The worker had observed that steam was blowing directly from the continuous blowdown pipe over his work position, which was on the feed hopper platform. A pH test of the steam from that pipe showed it was mildly caustic (pH 9), which was considered the cause of increased skin irritation sensitivity. Because boiler pH can change quickly and be at higher levels than was experienced, the hygienist recommended that all steam blowdowns and relief standpipes be fitted with condensate collection systems to prevent caustic precipitation in systems that do not have direct reading pH monitors.

D. SAMPLING

1. Methods/Protocols

The Versar sampling methods/protocols used during the MWP-2000 incinerator trial burn at NCBC are summarized in the following subsections.

a. Neat 1,2,4-TCB and HCE

Upon location of a quantity source for both POHCs, a representative grab sample was analyzed by INEL and ITAS Analytical laboratory personnel. This analysis was done to ensure that the POHCs were pure enough to provide sufficient POHC feed to demonstrate the six nine DRE requirement. Because of delivery schedule problems, the original source of the HCE was not available for the trial burns, and a backup supplier was located. The purity of the record source of HCE was not confirmed before the trial burns.

The purity of the POHCs used in the trial burn was determined by collecting and analyzing a randomly related sample of 1,2,4-TCB and HCE at the beginning of each test run by selecting a preweighed bottle of TCB

and a preweighed bottle of HCE. After all test runs were completed, two grab samples were collected in 40-mL volatile organic analysis (VOA) bottles from each preweighed container. For Runs 7B and 7C, two preweighed bottles of TCB were collected. One bottle contained clear TCB while the other contained darkened TCB. Two 40-mL VOA containers were also filled from each of these bottles. Only clear TCB samples were collected for Run 7A. It is uncertain why one batch of TCB was darker than the other batch.

b. Ash Drag (Treated Sand)

Grab samples of treated sand from the ash drag were obtained using a small clean sample scoop to catch samples as the ash fell off of the ash drag conveyor into the ash drag bin. Care was taken to collect individual grab samples from various locations in the soil stream. Sample collection began 30 minutes after the initiation of stack gas sampling and finished 30 minutes after the completion of stack gas sampling. Grab samples were taken at 15-minute intervals, and approximately three grab samples were needed to fill a 16-ounce sample jar. Each jar was completely filled and immediately sealed. At the end of each run, representative composite samples were prepared by manually homogenizing all individual grab samples collected during a run in a clean container.

Grab samples of the ash drag were also collected before all runs. Those samples were to serve as a check on the levels of potential background contamination. The samples were collected in the same manner described above.

c. Stack Gas

During all runs, two different EPA M5 stack sampling trains were used. The first was an MM5 train, which was used to sample for potential HCE and TCB in the stack gas. An M5 train, the second train, was used to independently quantify the amount of particulate and HCl in the stack gases. The M5 and MM5 sampling trains were identical for each test run and their configurations are shown schematically in Figure 23.

(1) MM5 Train Sampling Procedures

The MM5 sampling trains and their operation were in accordance with EPA Method 0010 (Reference 19). Each MM5 train (one for each test run) had an XAD module followed by four impingers. The first of the impingers was large enough to capture 2 liters of condensate. The XAD module was used to capture and quantify any potential HCE and TCB in the stack gas. To minimize the chance of field cross-contamination, the XAD modules were filled at the analytical laboratory after the XAD was cleaned. The sealed modules were opened only for insertion and removal from the MM5 train. The following samples were recovered from the MM5 train for each test run:

- Particulate filter: The filter was carefully removed with clean tweezers from its glass holder, placed in a clean Petri dish and sealed with Teflon^R tape.
- Probe rinse: The nozzle, probe, and front half of the filter holder and connecting glassware were brushed and rinsed with a 1:1 solution of methylene chloride/methanol, and the rinsate was collected in 8-ounce glass jars with Teflon^R-lined lids.
- XAD sorbent traps: The ends of the XAD tubes were sealed with Teflon^R upon removal from the train, wrapped in clean aluminum foil, and placed in a leak-proof plastic bag.
- Postfilter rinse: The back half of the filter holder, long tube, U-tube, and condenser were rinsed with a 1:1 solution of methylene chloride/methanol. The rinsate was collected in 8-ounce I Chem^R jars with Teflon^R-lined lids.
- Condensate: The liquid contents of the impingers were volumetrically measured and placed in 80-ounce amber glass bottles capped with Teflon^R-lined lids. Rinsing was performed using deionized water.

- Silica gel: The cartridge was returned to its original container and sealed after it was weighed. The weight was needed to determine the amount of residual moisture that reached this cartridge.

In addition to these samples, MM5 field, system, and trip blanks were also collected. The MM5 field blank was used to determine if any contamination of XAD occurred during the insertion and removal of the module. For this reason, only the XAD module was collected from the field blank. The XAD module from the MM5 field blank was collected in Test Run 7A and was obtained by briefly exposing the XAD sorbent to ambient air for approximately the same amount of time as it would take to insert and remove the module.

The MM5 system blank was used to determine if ambient air contributed to any contamination of MM5 samples as a result of leak testing. The system blanks were obtained posttest, after Test Run 7C. To obtain a valid MM5 system blank, a typical run was simulated: the incinerator was operated, and the POHCs were fed in the same manner as was done during Test Runs 7A, 7B, and 7C. The system was taken to the top of the stack where it was leak-tested in the same fashion and the same number of times as during a typical run. The following samples were collected from the system blank: the filter, XAD module, probe rinsate, and postfilter rinse.

The MM5 trip blank was used to determine if any XAD contamination occurred during shipment of samples. The MM5 trip blank consisted of an XAD module, which was shipped with samples from Test Run 7C.

(2) M5 Train Sampling Procedures

The second stack sampling train (M5) was set up to capture particulate and determine HCl concentration. The M5 trains looked exactly the same as the MM5, except they did not have XAD modules. As was the case with the MM5 trains, four impingers were used and the first

impinger was large enough to collect 2 liters of solution. Both the first and the second impingers were filled with 100 mL of 0.1 N NaOH before each run. The primary function of the first impingers was to collect condensate, and the alkaline solution in the second impinger was used to determine chlorides. Viton O-rings were used to seal the first impinger and all joints upstream.

The probe rinsate and particulate filter in the M5 train were used to quantify the amount of particulate captured. The probe rinsate was collected for each run and sent to the analytical laboratory for particulate analysis. The total amount of particulate was determined by adding the amount contained in the probe rinsate to the amount captured on the particulate filter. The following procedure was used to quantify the amount of particulate on the filter:

- Step 1: Dry filters in desiccant box for a minimum of 24 hours
- Step 2: Prewrite each filter and record weight
- Step 3: Use filter for M5 test
- Step 4: Dry filter for 24 hours in desiccant box
- Step 5: Weigh filter
- Step 6: Dry filter in desiccant box for an additional 8 hours
- Step 7: Reweigh filter to confirm no additional weight loss
- Step 8: Discard the filter.

All drying was performed at ambient temperatures in a clean drying box constructed of stainless steel and glass. The drying box was located inside the sample trailer, which was maintained at a room temperature of nominally 70°F. Approximately 500 grams of silica gel were placed in the drying box as a drying agent. The silica gel was replaced when a color change from blue to pink was observed.

The following samples were recovered from the M5 train for each run:

- Particulate filter: The particulate filter was carefully removed from its glass holder and weighed according to the procedure described previously to determine the amount of particulate captured.
- Probe rinse: The nozzle, probe, and front half of the filter holder and connecting glassware were rinsed with acetone, and the rinsate was collected in 8-ounce glass jars with Teflon^R-lined lids. The probe rinse was analyzed for total particulate only.
- Condensate: The contents of the impingers were volumetrically measured and placed in 80-ounce amber glass sample bottles with Teflon^R-lined lids.

(3) Sample Locations

The sampling location and number of traverse points for the MM5 and M5 sampling were determined after a presurvey, which was performed according to procedures for sample and velocity traverses for stationary sources in EPA Reference Method 1 (Appendix A to 40 CFR 60). Based on an inside stack diameter of 30 inches, and the fact that the sampling ports are greater than eight stack diameters downstream of any flow disturbances, six sampling point locations were established on two perpendicular stack cross sections. Because two different trains were operated simultaneously, the MM5 train began sampling at the farthest point on one perpendicular while the M5 began sampling at the closest point on the perpendicular.

(4) Calibration

Before all test runs, MM5 and M5 dry gas meters were calibrated in accordance with M5 procedures as follows: a spirometer was

used to calibrate a certified dry gas meter, and the certified dry gas meter was then used to calibrate the MM5 and M5 meters. The gas meters, final impinger, filter, and stack temperature sensor were calibrated against an ASTM (American Society for Testing and Materials) mercury-in-glass thermometer before all runs. The MM5 and M5 S-type pitot tubes were constructed according to the design criteria in EPA Reference Method 2, Determination of Stack Gas Velocity and Volumetric Flow Rate (Type 5 pitot tube) and were calibrated in a wind tunnel. Nozzles used in the MM5 and M5 sampling trains were calibrated to the nearest 0.025 mm (0.001 inch), and the stack was checked for cyclonic flow. After the completion of all test runs, the dry gas meters from both trains were recalibrated.

Stack gas moisture and velocity were determined concurrent with the MM5 sampling activity using procedures in EPA Reference Method 4 (Appendix A to 40 CFR 60), Determination of Moisture Content in Stack Gas. Stack gas molecular weight was also determined concurrently according to procedures in EPA Reference Method 3 (Appendix A to 40 CFR 60), Gas Analysis for Carbon Dioxide, Excess Air, and Dry Molecular Weight. During each test, carbon dioxide and oxygen content in the stack gases were measured using an Orsat. Before each run, the Orsat was leak-checked and calibrated.

Actual calibration and in-field data logs were maintained on a portable computer for ease of reference and data collection and reduction.

d. Effluent Neutralization Tank

Effluent neutralization tank samples were collected via a sample port located immediately after the quench recirculation pumps. Before sample collection, the port was emptied of any potentially stagnant liquid. Before all test runs, a background sample of water was collected in a 1-quart amber glass jar. At the completion of each test run, grab samples of the water were collected in four 1-quart amber glass jars. All sample jars were filled directly from the sample port and had Teflon^R-lined lids.

e. Quench/Scrubber Fines

Quench/scrubber fines samples were obtained from the end of the discharge line that dumps the fines into the settling tank. The fines were concentrated in a Lamella clarifier, which is part of the ENT. This sample port was also emptied of any potentially stagnant liquid, and four 1-quart amber glass jars with Teflon^R-lined lids were directly filled from the port.

f. Background Samples

Stock supplies of all reagents used in both MM5 and M5 stack sampling trains were premixed before the beginning of the trial burn. Background samples of these reagents, which included a 1:1 solution of methylene chloride/methanol, acetone, and 0.1 N NaOH, were collected directly from reagent bottles.

Sand and feedstock samples were collected before the initiation of Test Run 7A. These samples are essentially the same (both are samples of unspiked sand), except they were collected at two physically different points. The sand samples were collected from stockpiled sand stored in two tents located near the incinerator, and the feedstock backgrounds were obtained from the feed conveyor belt. If any contamination of the feed occurred from the time it was transported from the stockpile to the conveyor belt, the results would be a contaminated feedstock background.

A background sample of the supply water to the incinerator was also collected before Test Run 7A from a supply water tap.

g. Sampling Duration

The duration of each run ranged from 5 to 7 hours, which was the time required to obtain 240 minutes of continuous stack gas samples for

the MM5 and M5 trains, including leak-testing. All sampling activities were scheduled around stack gas sampling.

h. Sample Preservation and Shipment

All samples collected were placed in their appropriate containers and preserved as required. All liquid samples and samples collected from the MM5 and M5 were maintained and shipped on ice; no preservation method was required for the solid samples as stated in the approved Trial Burn Plan (Reference 21). However, because ash drag samples were shipped with ENT water samples in the same cooler, ash drag samples were shipped on ice. All samples shipped to the laboratory were packaged and shipped in accordance with applicable Department of Transportation regulations. All analytical laboratory shipments were sent via Federal Express to meet analysis time constraints specified by methods in EPA SW-846 (Reference 19).

i. Sample Tracking Management

All sample containers were labeled with the upper portion of the Versar's standard three-part label. The duplicate label was affixed to containers in which the sample jars were packaged. The lower portion of the sample label was placed (as appropriate) into the field logbook as a cross-check mechanism for sample identification. If a sample was improperly labeled, the label was discarded and the next sample number in the sequence was used.

All samples were tracked using Versar's standard chain of custody form. Custody of the samples began at the time of sample collection and was maintained by the sampling team supervisor until samples were relinquished for shipment to ITAS in Knoxville, Tennessee, for analysis.

2. Samples Collected

Table 10 lists the samples collected during the trial burn at NCBC. The samples are categorized according to each run (background, 7A, 7B, 7C, or posttest). Table 10 also lists the sample type, sample number, analysis, and method of preservation used for each sample collected. Figure 22 is a schematic diagram of the incinerator showing the locations where the samples were collected. Figures 41, 42, and 43 show the sample collection schedule for Test Runs 7A, 7B, and 7C, respectively.

3. Stack Gas Operating Parameters

Table 11 summarizes the in-field stack sampling operating parameters from the three test runs.

4. Stack Gas Field Results

The particulate concentration and mass rate data for the three test runs are summarized below from Table 11.

<u>Parameter</u>	<u>Run 7A</u>	<u>Run 7B</u>	<u>Run 7C</u>
Particulate concentration (corrected to 7 percent oxygen), mg/dscm	12.0	23.0	23.4
Particulate mass rate, gram/hour	169.4	329.0	343.6

These results are well below permit limits and are discussed further in Section VI. Analytical results for the POHCs in the other samples are presented in Section V.B.

TABLE 10. SUMMARY OF SAMPLES TAKEN DURING MWP-2000 INCINERATOR SYSTEM TRIAL BURN AT NCBC

Test Run	Sample	Sample Type	Versar Sample Number	Planned Analysis	Method of Preservation
Background	Methylene chloride/methanol	Background	27501	Archived	Packed in ice
	Acetone	Background	27502	Archived	Packed in ice
	Alkaline solution	Background	27503	Archived	Packed in ice
	Sand	Background	27504	Archived	None required
	Sand	Duplicate	27504	Archived	None required
	Tap Water	Background	27505	Archived	Packed in ice
	Unspiked feedstock	Background	27506	HCE, TCB	None required ^a
	Unspiked feedstock	Background	27508	HCE, TCB	None required ^a
	Ash drag	Background	27509	HCE, TCB	None required ^a
	Ash drag	Background	27510	HCE, TCB	None required ^a
	ENT Water	Background	27520	Archived	Packed in ice
7A	HCE ^b	Grab	27649	HCE, TCB	Packed in ice
	HCE ^b	Grab	27650	HCE, TCB	Packed in ice
	TCB ^b clear	Grab	27646	HCE, TCB	Packed in ice
	TCB ^b clear	Grab	27647	HCE, TCB	Packed in ice
	Ash drag	Composite	27550	HCE, TCB	Packed in ice ^c
	Ash drag	Composite	27551	HCE, TCB	Packed in ice ^c
	Ash drag	Duplicate	27552	HCE, TCB	Packed in ice ^c
	Ash drag	Duplicate	27553	HCE, TCB	Packed in ice ^c
	ENT water	Grab	27556	Archived	Packed in ice
	ENT water	Grab	27557	Archived	Packed in ice
	ENT water	Grab	27558	Archived	Packed in ice
	ENT water	Grab	27559	Archived	Packed in ice
	MMS	Filter	27560	HCE, TCB	Packed in ice
	MMS	Probe rinsate	27561	HCE, TCB	Packed in ice
	MMS	XAD	27652	HCE, TCB	Packed in ice
	MMS	Post-filter rinse	27563	HCE, TCB	Packed in ice
	MMS	Condensate	27564	HCE, TCB	Packed in ice
	MMS	Condensate	27565	HCE, TCB	Packed in ice
	MMS field blank	XAD	27577	HCE, TCB	Packed in ice
	MS	Filter ^b	NA ^d	Particulate	NA
	MS	Condensate	27566	Chlorides	Packed in ice
	MS	Probe rinse	27568	Particulate	Packed in ice
7B	HCE ^b	Grab	27655	HCE, TCB	Packed in ice
	HCE ^b	Grab	27656	HCE, TCB	Packed in ice
	TCB ^b clear	Grab	27651	HCE, TCB	Packed in ice
	TCB ^b clear	Grab	27652	HCE, TCB	Packed in ice
	TCB ^b dark	Grab	27653	HCE, TCB	Packed in ice
	TCB ^b dark	Grab	27654	HCE, TCB	Packed in ice
	Ash drag	Composite	27573	HCE, TCB	Packed in ice ^c
	Ash drag	Composite	27574	HCE, TCB	Packed in ice ^c
	Ash drag	Duplicate	27575	HCE, TCB	Packed in ice ^c
	Ash drag	Duplicate	27576	HCE, TCB	Packed in ice ^c
	ENT water	Grab	27569	Archived	Packed in ice

TABLE 10. SUMMARY OF SAMPLES TAKEN DURING MWP-2000 INCINERATOR SYSTEM TRIAL BURN AT NCBC (CONTINUED)

Test Run	Sample	Sample Type	Versar Sample Number	Planned Analysis	Method of Preservation
78	ENT water	Grab	27570	Archived	Packed in ice
(Continued)	ENT water	Grab	27571	Archived	Packed in ice
	ENT water	Grab	27572	Archived	Packed in ice
	MM5	Filter	27580	HCE, TCB	Packed in ice
	MM5	Probe rinsate	27578	HCE, TCB	Packed in ice
	MM5	XAD	27591	HCE, TCB	Packed in ice
	MM5	Post-filter rinse	27579	HCE, TCB	Packed in ice
	MM5	Condensate	27589	HCE, TCB	Packed in ice
	MM5	Condensate	27590	HCE, TCB	Packed in ice
	M5	Filter ^b	NA	Particulate	NA
	M5	Condensate	27593	Chlorides	Packed in ice
	M5	Condensate	27594	Chlorides	Packed in ice
	M5	Probe rinse	27592	Particulate	Packed in ice
7C	HCE ^a	Grab	27651	HCE, TCB	Packed in ice
	HCE ^a	Grab	27562	HCE, TCB	Packed in ice
	TCB ^a clear	Grab	27657	HCE, TCB	Packed in ice
	TCB ^a clear	Grab	27658	HCE, TCB	Packed in ice
	TCB ^a dark	Grab	27659	HCE, TCB	Packed in ice
	TCB ^a dark	Grab	27660	HCE, TCB	Packed in ice
	Ash drag	Composite	27613	HCE, TCB	None required
	Ash drag	Composite	27614	HCE, TCB	None required
	Ash drag	Duplicate	27615	HCE, TCB	None required
	Ash drag	Duplicate	27616	HCE, TCB	None required
	ENT water	Grab	27623	HCE, TCB	Packed in ice
	ENT water	Grab	27624	HCE, TCB	Packed in ice
	ENT water	Grab	27625	HCE, TCB	Packed in ice
	ENT water	Grab	27626	HCE, TCB	Packed in ice
	MM5	Filter	27608	HCE, TCB	Packed in ice
	MM5	Probe rinsate	27611	HCE, TCB	Packed in ice
	MM5	XAD	27627	HCE, TCB	Packed in ice
	MM5	Post-filter rinse	27612	HCE, TCB	Packed in ice
	MM5	Condensate	27628	HCE, TCB	Packed in ice
	MM5	Condensate	27629	HCE, TCB	Packed in ice
	M5	Filter ^b	NA	Particulate	NA
	M5	Condensate	27630	Chlorides	Packed in ice
	M5	Condensate	27631	Chlorides	Packed in ice
	M5	Probe rinse	27610	Particulate	Packed in ice
Posttest	ENT fines	Grab	27645	Archive	None required
	Post-carbon absorption	Grab	27635	Archive	Packed in ice
	Post-carbon absorption	Grab	27636	Archive	Packed in ice
	Post-carbon absorption	Grab	27637	Archive	Packed in ice
	Post-carbon absorption	Grab	27638	Archive	Packed in ice

TABLE 10. SUMMARY OF SAMPLES TAKEN DURING MWP-2000 INCINERATOR SYSTEM TRIAL BURN AT NCBC (CONCLUDED)

<u>Test Run</u>	<u>Sample</u>	<u>Sample Type</u>	<u>Versar Sample Number</u>	<u>Planned Analysis</u>	<u>Method of Preservation</u>
Posttest	MM5 system blank	Filter	27639	HCE, TCB	Packed in ice
(Continued)	MM5 system blank	XAD	27643	HCE, TCB	Packed in ice
	MM5 system blank	Condensate	27642	HCE, TCB	Packed in ice
	MM5 system blank	Probe rinsate	27640	HCE, TCB	Packed in ice
	MM5 system blank	Post filter rinse	27641	HCE, TCB	Packed in ice
	MM5 trip blank	XAD	27644	HCE, TCB	Packed in ice

a. Sample collected in 40-mL VOAS. For TCB samples clear and dark refer to color of the samples.

b. M5 Filters were weighed onsite.

c. These samples were therefore not shipped.

d. NA = Not applicable.

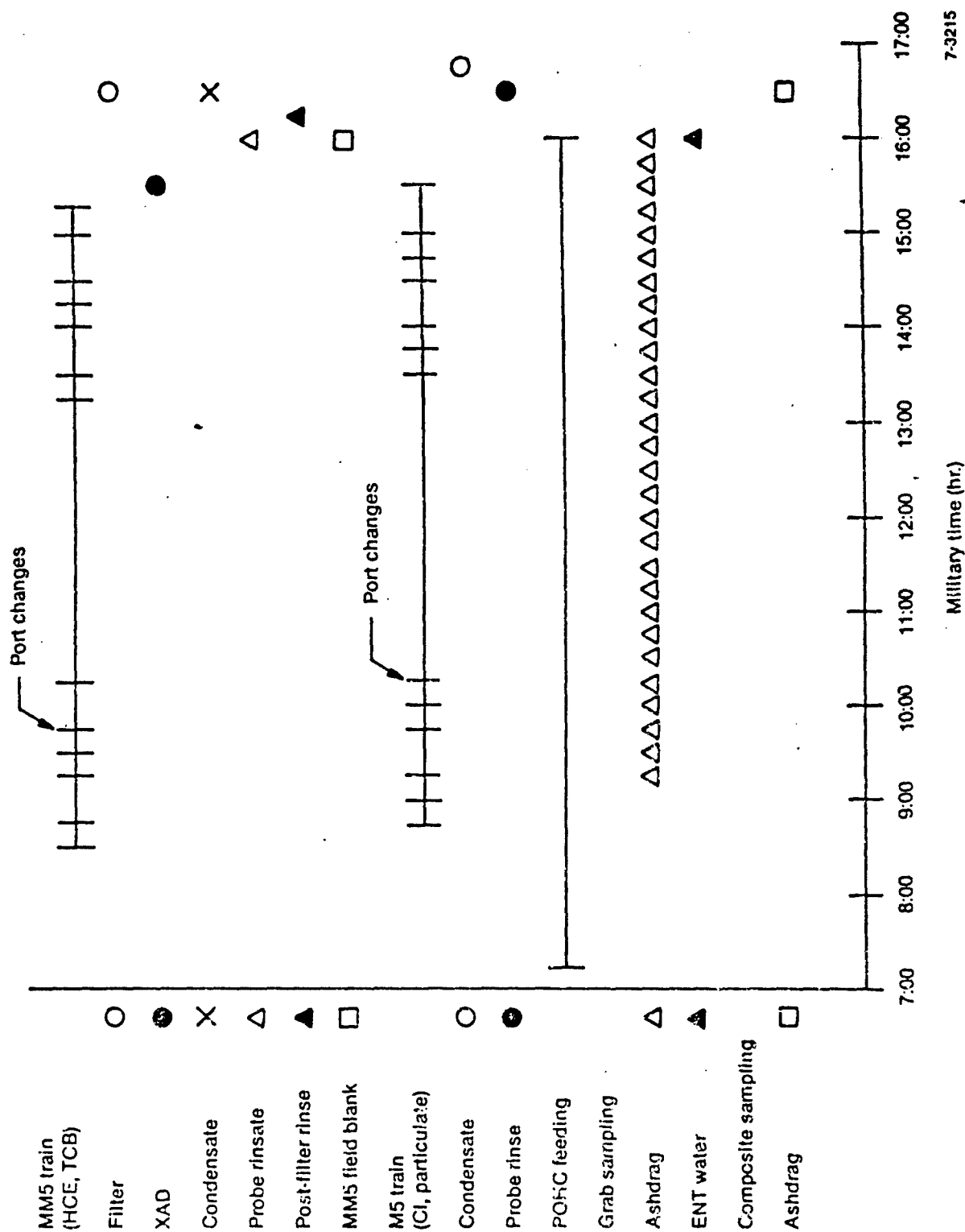


Figure 41. Sample collection and schedule for Trial Burn Test Run 7A.

Run 7B: 5/12/87

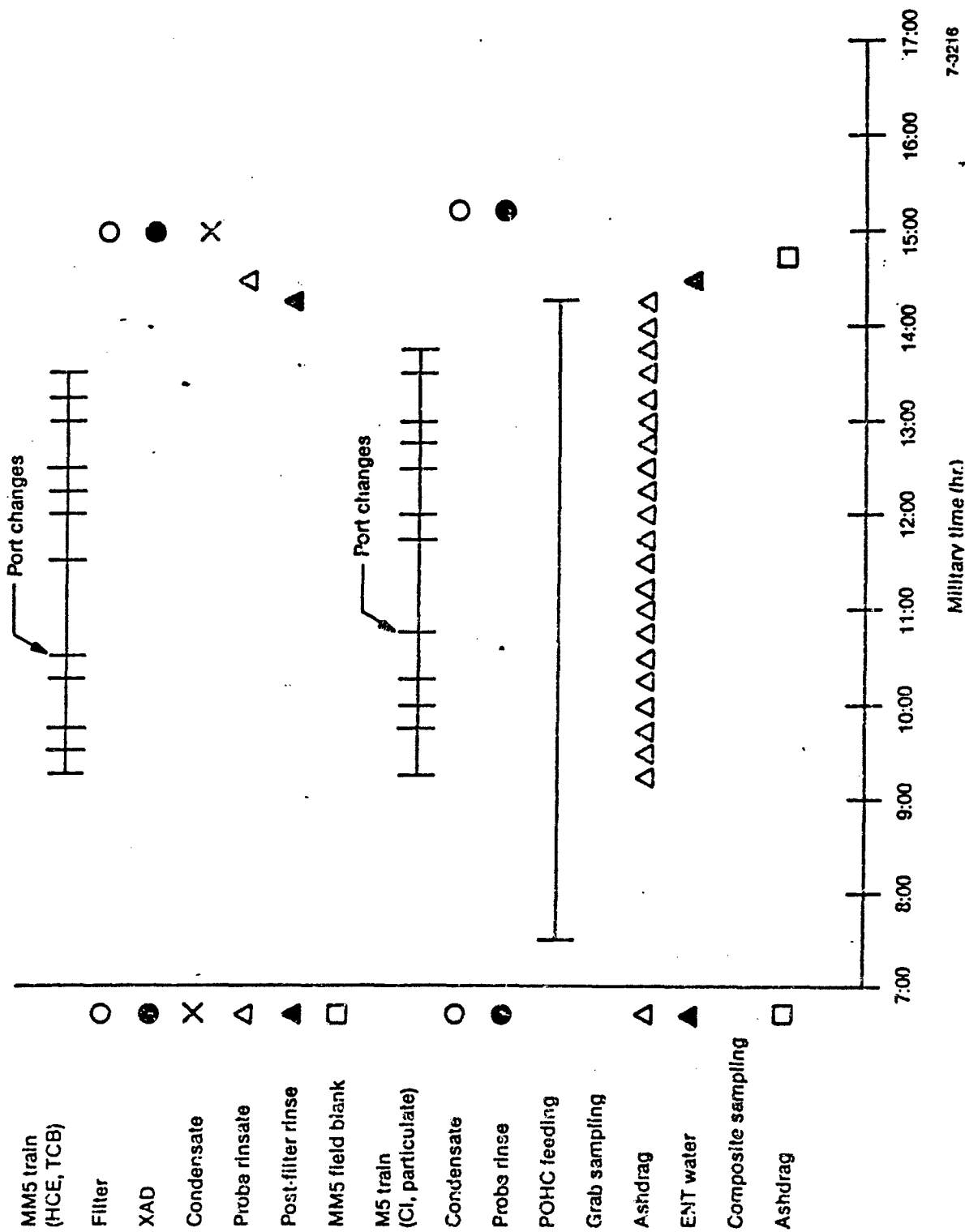
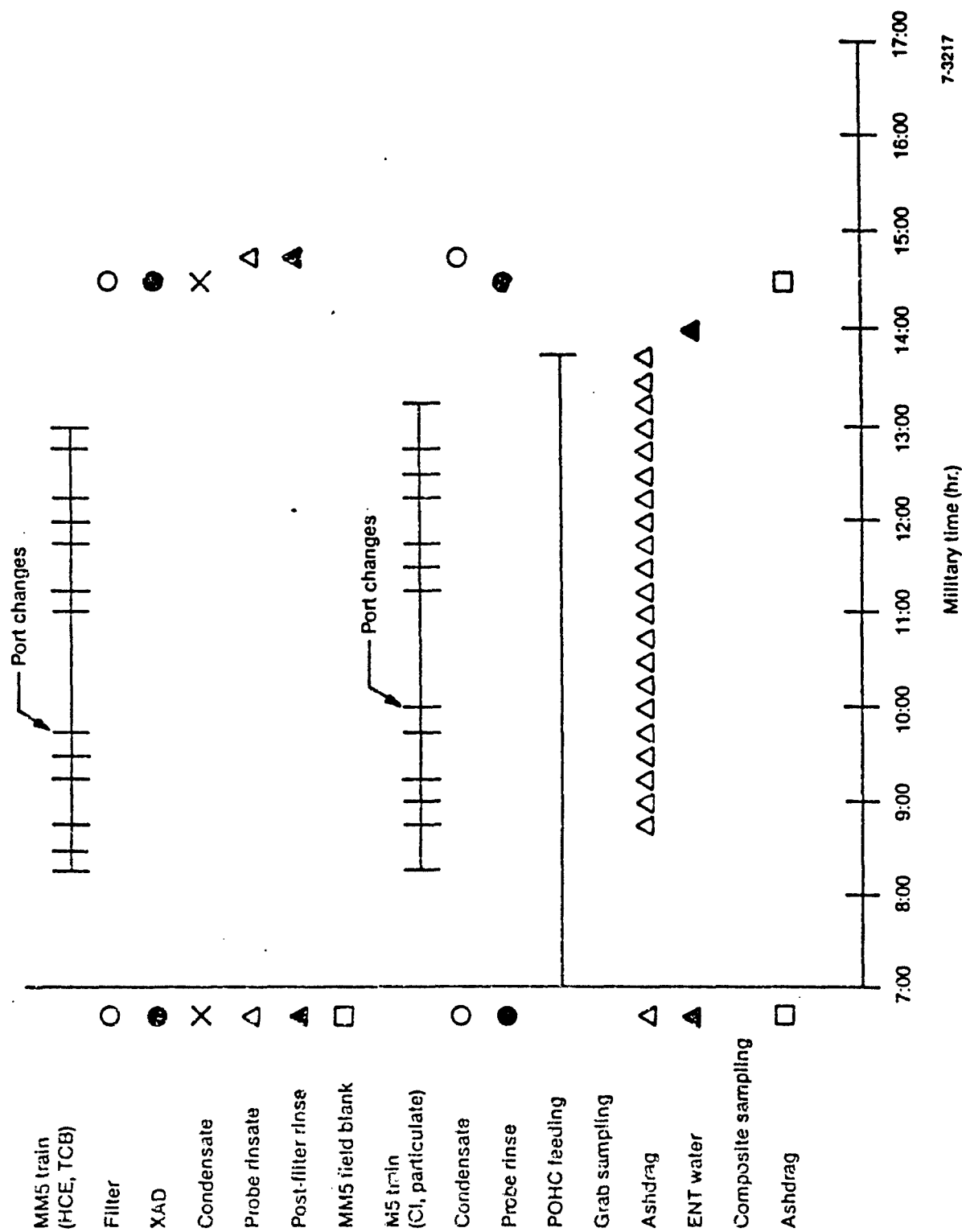


Figure 42. Sample collection and schedule for Trial Burn Test Run 7B.



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Figure 43. Sample collection and schedule for Trial Burn Test Run 7C.

TABLE 11. SUMMARY OF STACK TEST (MM5 AND M5) OPERATING DATA FOR MWP-2000 INCINERATOR SYSTEM TRIAL BURN AT NCBC

Parameter	Units	Test Burn ^a					
		7A		7B		7C	
		MM5	M5	MM5	M5	MM5	M5
1. Time							
Start	hour	0830	0840	0850	0900	0810	0820
Finish	hour	1515	1530	1335	1345	1300	1310
Duration of sampling	minute	240	240	240	240	240	240
2. Total number of sampling points	--	12	12	12	12	12	12
3. Meter calibration factor	--	0.988	0.995	0.988	0.995	0.988	0.995
4. Orifice calibration factor	--	1.759	1.564	1.759	1.564	1.759	1.564
5. Nozzle specifications							
Diameter	in.	0.25	0.25	0.25	0.25	0.25	0.25
Area	ft ²	3.41E-4	3.41E-4	3.41E-4	3.41E-4	3.41E-4	3.41E-4
6. Pitot tube coefficient	--	0.831	0.831	0.831	0.831	0.831	0.831
7. Average orifice pressure drop	in. H ₂ O	0.978	0.804	0.980	0.801	1.055	0.833
8. Volume of dry gas sampled	ft ³	128.159	132.364	131.750	133.135	136.452	137.322
9. Average gas meter temperature	°R	534.4	555.3	536.0	557.5	538.6	559.4
10. Barometric pressure	in. Hg	30.04	30.04	29.99	29.99	29.96	29.96
11. Static stack pressure	in. H ₂ O	-0.66	-0.66	-0.70	-0.70	-0.74	-0.74
12. Absolute stack pressure	in. Hg	29.99	29.99	29.94	29.94	29.91	29.91
13. Volume of gas sampled (standard)	dscf	125.812	125.858	128.751	125.898	132.578	129.294

TABLE 11. SUMMARY OF STACK TEST (MMS AND M5) OPERATING DATA FOR MWP-2000 INCINERATOR SYSTEM TRIAL BURN AT NCBC (CONTINUED)

Parameter	Units	Test Burn ^a					
		7A		7B		7C	
		MMS	M5	MMS	M5	MMS	M5
14. Volume of water collected in impingers and silica gel	mL	3667	3596	3599	3466	3950	3819
15. Volume of water collected based on saturated conditions	mL	3487	3487	3716	3716	3721	3721
16. Volume water vapor condensed in impingers	scf	171.15	166.91	168.13	160.79	184.42	178.07
17. Volume water vapor condensed in silica gel	scf	1.45	2.36	1.27	1.39	1.52	1.65
18. Percent moisture by volume	percent	57.84	57.36	56.82	56.30	58.38	58.16
19. Percent moisture by saturation	percent	56.61	56.61	57.60	57.60	56.91	56.91
20. Hole fraction of dry gas	F _{hd}	0.4339	0.4339	0.4240	0.4240	0.4309	0.4309
21. Gas analysis							
Average CO ₂ by volume	percent	8.20	8.20	8.24	8.25	8.59	8.59
Average O ₂ by volume	percent	5.88	5.88	5.62	5.58	5.50	5.50
Average CO by volume	percent	0.00	0.00	0.00	0.00	0.00	0.00
22. Dry molecular weight of stack gas	lb/lb-mol	29.55	29.55	29.54	29.54	29.59	29.59
23. Molecular weight at stack conditions	lb/lb-mol	23.01	23.01	23.00	23.00	22.99	22.99

TABLE 11. SUMMARY OF STACK TEST (MMS AND M5) OPERATING DATA FOR HWP-2000 INCINERATOR SYSTEM TRIAL BURN AT NCBC (CONCLUDED)

Parameter	Units	Test Burn					
		7A		7B		7C	
		MMS	M5	MMS	M5	MMS	M5
24. Average stack temperature	°R	646	646	645	645	647	647
25. Average stack gas velocity	ft/sec	76.27	73.27	78.00	74.65	79.74	75.29
26. Stack area	sq-in.	706.9	706.9	706.9	706.9	706.9	706.9
27. Actual stack gas flow rate	scfh	1,347,823	1,294,804	1,378,443	1,319,091	1,409,072	1,330,044
28. Dry stack gas flow rate (standard)	scfh	479,362	460,506	478,675	458,125	495,142	467,632
29. Isokinetic rate	percent	97.8	100.4	95.6	96.3	100.4	102.8
30. Weight of filterable particulates	mg	--	46.3	--	90.4	--	95.0
31. Particulate concentration (at standard conditions)	lb/dscf mg/dscf mg/dscm	-- -- --	8.11E-10 0.37 12.990	-- -- --	1.58E-9 0.72 25.354	-- -- --	1.62E-9 0.73 25.944
32. Particulate concentration (corrected to 7 percent oxygen)	lb/dscf mg/dscf mg/dscm	-- -- --	7.50E-10 0.34 12.0	-- -- --	1.44E-9 0.65 23.0	-- -- --	1.46E-9 0.66 23.4
33. Particulate concentration (corrected to 12 percent carbon dioxide)	lb/dscf mg/dscf mg/dscm	-- -- --	1.19E-9 0.54 19.0	-- -- --	2.30E-9 1.04 36.9	-- -- --	2.26E-9 1.03 36.2
34. Particulate mass rate	lb/hr g/hr	-- --	3.74E-4 169.4	-- --	7.25E-4 329.0	-- --	7.58E-04 343.6

V. SAMPLE ANALYSIS

A. ANALYTICAL METHODS

The analyses used for each trial burn sample are listed in Table 12, along with the analytical methods for both extraction and analysis. Special procedures or other considerations, related to the other analyses, are discussed below. All analyses for organic compounds were by capillary column GC/MS.

Analyses for hexachloroethane and trichlorobenzene were conducted by standard SW-846 methods, as specified in Table 12, and may be referred to in Section 9B of the Quality Assurance Project Plan (Appendix B). The hexachloroethane and trichlorobenzene were analyzed neat instead of in a soil matrix, because of the alternate method of POHC addition.

B. SAMPLE RECOVERY PROCEDURES

The procedures for recovering compounds from the major sample groups are briefly summarized below.

1. Low Concentration Water

Approximately 1000 mL of the sample were transferred into a 2-liter separatory funnel. The sample was spiked with the surrogate standard solution, and the pH was adjusted to >11 with 10 N sodium hydroxide. The sample was triple extracted with methylene chloride, and the extracts were combined and labeled as the base/neutral fraction. The sample was again adjusted to a pH of >2 with sulfuric acid (1 + 1) and triple extracted with methylene chloride. The extracts were combined and labeled as the acid fraction. The resulting extracts were filtered through conditioned sodium sulfate and concentrated to a volume of 1.0 mL with a Kuderna-Danish (K-D) apparatus.

TABLE 12. ANALYSES PERFORMED FOR NCBC TRIAL BURN

Test	Sample	Matrix	Type	Target(s)	Analysis	Extraction
Background						
	Feed stock	Solid	Background	HCE, TCB	8270 GC/MS	3550 Sonication
	Ash drag	Solid	Background	HCE, TCB	8270 GC/MS	3550 Sonication
	ENT	Liquid	Background	Archive	-- ^a	
	Potable	Liquid	Background	Archive	-- ^a	
	Sand	Solid	Background	Archive	-- ^a	
	Acetone Wash	Liquid	Background	Archive	-- ^a	
	Caustic	Liquid	Background	Archive	-- ^a	
Run 7-A						
	Feed stock	Solid	Composite	NCE, TCB	SW846-8270 GC/MS	SW846-8270 Sonication
	Feed stock	Solid	Duplicate	NCE, TCB	SW846-8270 GC/MS	SW846-8270 Sonication
	Ash drag	Solid	Composite	NCE, TCB	SW846-8270 GC/MS	SW846-8270 Sonication
	ENT	Liquid	Grab	Archive	-- ^a	
	MM5	Solid	Filter	HCE, TCB	SW846-8270 GC/MS	SW846-3540 Soxhlet
	MM5	Solid	XAD	HCE, TCB	SW846-8270 GC/MS	SW846-3540 Soxhlet
	MM5	Liquid	Condensate	HCE, TCB	SW846-8270 GC/MS	SW846-3510 L/L Funnel
	MM5	Liquid	Rinsate	HCE, TCB	SW846-8270 GC/MS	SW846-3510 L/L Funnel
	MM5	Solid	Field Blank	HCE, TCB	SW846-8270 GC/MS	SW846-3540 Soxhlet
	Method 5	Solid	Filter	Particulate	EPA Method 5	
	Method 5	Liquid	Rinsate	Particulate	EPA Method 5	
	Method 5	Liquid	Caustic	HCl	EPA Method 325.3	
Run 7-B						
	Feed stock	Solid	Composite	HCE, TCB	SW846-8270 GC/MS	SW846-3550 Sonication
	Feed stock	Solid	Duplicate	HCE, TCB	SW846-8270 GC/MS	SW846-3550 Sonication
	Ash drag	Solid	Composite	HCE, TCB	SW846-8270 GC/MS	SW846-3550 Sonication
	ENT	Liquid	Grab	Archive	-- ^a	
	MM5	Solid	Filter	HCE, TCB	SW846-8270 GC/MS	SW846-3540 Soxhlet
	MM5	Solid	XAD	HCE, TCB	SW846-8270 GC/MS	SW846-3540 Soxhlet
	MM5	Liquid	Condensate	HCE, TCB	SW846-8270 GC/MS	SW846-3510 L/L Funnel
	MM5	Liquid	Rinsate	HCE, TCB	SW846-8270 GC/MS	SW846-3510 L/L Funnel
	MM5 Blank	Solid	Field Blank	HCE, TCB	SW846-8270 GC/MS	SW846-3540 Soxhlet
	Method 5	Solid	Filter	Particulate	EPA Method 5	
	Method 5	Liquid	Rinsate	Particulate	EPA Method 5	
	Method 5	Liquid	Caustic	HCl	EPA Method 325.3	

TABLE 12. ANALYSES PERFORMED FOR NCBC TRIAL BURN (CONCLUDED)

Test	Sample	Matrix	Type	Target(s)	Analysis	Extraction
Run 7-C						
	Feed stock	Solid	Composite	HCE, TCB	SW846-8270 GC/MS	SW846-3550 Sonication
	Feed stock	Solid	Duplicate	HCE, TCB	SW846-8270 GC/MS	SW846-3550 Sonication
	Ash drag	Solid	Composite	HCE, TCB	SW846-8270 GC/MS	SW846-3550 Sonication
	ENT	Liquid	Grab	Archive	-- ^a	
	MMS	Solid	Filter	HCE, TCB	SW846-8270 GC/MS	SW846-3540 Soxhlet
	MMS	Solid	XAD	HCE, TCB	SW846-8270 GC/MS	SW846-3540 Soxhlet
	MMS	Liquid	Condensate	HCE, TCB	SW846-8270 GC/MS	SW846-3510 L/L Funnel
	MMS	Liquid	Rinsate	HCE, TCB	SW846-8270 GC/MS	SW846-3510 L/L Funnel
	MMS Blank	Solid	Field Blank	HCE, TCB	SW846-8270 GC/MS	SW846-3540 Soxhlet
	Method 5	Solid	Filter	Particulate	EPA Method 5	
	Method 5	Liquid	Rinsate	Particulate	EPA Method 5	
	Method 5	Liquid	Caustic	HC1	EPA Method 325.3	
Posttest						
	ENT Fines ^b	Solid	Grab	HCE, TCB	SW846-8270 GC/MS	SW846-3550 Sonication

a. Analyzed only if contamination is suspected.

b. Analyzed only if scrubber fines are present.

2. Low-Concentration Soil

The feedstock sand, the background sand, and the ash drag sand were considered Low-Concentration soil. For those samples, a 30-gram portion of sample was mixed with 30 grams of anhydrous sodium sulfate in a beaker. The sample was spiked with surrogate standards and triple-extracted with 1:1 methylene chloride/acetone, using an ultrasonic probe. The extracts were filtered, combined, and concentrated to a volume of 10 mL with a K-D apparatus. The 10-mL extract was concentrated to a volume of 1.0 mL for GC/MS analysis of base/neutral/acid (BNA) extractables.

3. Medium-Concentration Soil

The sand that was mixed with POHC before the trial burn is considered Medium-Concentration soil. For those samples, a 1.0-gram portion of sample was mixed with 2.0 grams of anhydrous sodium sulfate in a beaker. The sample was spiked with surrogate standards and extracted with methylene chloride, using an ultrasonic probe. The extract was filtered, and 5.0 mL was concentrated to a volume of 1.0 mL with a K-D apparatus.

4. Modified Method 5 Sampling Train

The components of the MM5 sampling train were extracted separately. The XAD-2 resin and the filter were Soxhlet^R-extracted for 16 hours with methylene chloride. Surrogate standards were added to the XAD-2 resin before extraction. The condensate was triple-extracted with methylene chloride. The probe rinse and postfilter rinse were dried with sodium sulfate. All resulting extracts were combined and concentrated to a volume of 1.0 mL and analyzed by GC/MS for BNAs.

C. POHC CHARACTERIZATION

Upon location of a quantity source for both POHCs, a representative grab sample was analyzed by INEL and ITAS Analytical Laboratory personnel. Because of delivery schedule problems, the original source for HCE was not

available for the trial burn, and a backup supplier was located. Because of this change, the initial analytical screenings of HCE are not relevant as this source was not used. A high-purity HCE source was located and the analytical results from the POHC container samples confirm that the compound is 99+ percent pure HCE.

D. DETECTION LIMIT CALCULATIONS

The initial detection limit specified at the beginning of the project was 10 μg per compound on the MM5 sample train. During the course of the project it was determined that, due to the low level of feed material, the laboratory would need to extend the instrument detection limit by one order of magnitude (1 $\mu\text{g}/\text{train}$). The sample train components had been extracted, combined, and concentrated to 1 mL. The GC/MS instrument would need to detect 1 ppm in the extract to achieve this detection limit.

To determine the instrument detection limit at this level, the procedure outlined in the EPA contract Laboratory Program Statement of Work--7/85 Revision was used. The instrument detection limit was calculated as three times the standard deviation of the measured values of standards run at three to five times the required detection limit concentrations. Standards were analyzed at a concentration of 2 $\mu\text{g}/\text{mL}$. The results are included in the raw data previously submitted and are summarized below. The calculated instrument detection limits are well below the reported qualification limit of 1 $\mu\text{g}/\text{train}$. These standards were run during the analysis sequence, both before and after actual samples.

Hexachloroethane and 1,2 - Trichlorobenzene
Instrument Detection Limits

<u>File ID</u>	<u>Date</u>	<u>Time</u>	<u>HCE</u>	<u>TCB</u>
BNA20520	05/20/87	10:00	1.91	2.01
BNA20522	05/22/87	09:06	2.14	2.25
BNA205222	05/22/87	17:04	2.24	2.07
Mean			2.10	2.11
Std.Dev.			0.168	0.125
Instrument Detection Limit			0.504	0.375

VI. ANALYTICAL AND PERFORMANCE RESULTS

A. ANALYTICAL RESULTS

This section presents the results of the various analyses performed on the samples collected for the NCBC trial burn. Table 13 summarizes the raw data results. The calculated performance results are discussed in Section VI.B.

1. MM5 Results

For each test the MM5 filter extractant, the probe rinse, the XAD extractant, and the postfilter probe rinse were composited and analyzed as one sample. There was no quantified detection of either POHC in any MM5 stack sample. The detection limit for HCE was 1 $\mu\text{g}/\text{sample train}$. Runs 7A and 7B showed the presence of trace quantities of TCB that were greater than zero but less than the quantitation limit.

2. Ash Residue Results

There was no quantified detection of either POHC in any of the ash composite samples. The observed detection limit was 330 $\mu\text{g}/\text{kg}$.

3. ENT Tower Liquor Results

The ENT liquor sample, taken after all testing was completed, was found to be free of both POHCs. The observed detection limit was 10 $\mu\text{g}/\text{l}$. Because this is a closed (recycle) system, samples taken after runs 7A and 7b were assumed to be similarly free of POHC. If the sample taken after run 7C showed any detectable POHC, it was planned to analyze the archived samples for runs 7A and 7B.

TABLE 13. SUMMARY OF ANALYTICAL RESULTS

	<u>Pretest Composite</u>	<u>7A</u>	<u>7B</u>	<u>7C</u>	<u>Posttest Composite</u>
Ash Drag					
HCE $\mu\text{g/kg}$	<330	<330	<330	<330	--
TCB $\mu\text{g/kg}$	<330	<330	<330	<330	--
Modified Method 5					
HCE $\mu\text{g/sample train}$	--	<1	<1	<1	<1
TCB $\mu\text{g/sample train}$	--	<0.14 J	<0.25 J	<1	<1
Method 5					
Condensate for chlorides ($\mu\text{g/sample train}$)	--	32	11	6	--
Particulate filter ($\mu\text{g/sample train}$)	--	46.3	91	95	--
Particulate probe rinse ($\mu\text{g/sample train}$)	--	27	35	180	--
Feedstock Sand HCE $\mu\text{g/kg}$ (unspiked)	<330	--	--	--	--
Feedstock Sand TCB $\mu\text{g/kg}$ (unspiked)	<330	--	--	--	--
Neat HCE for HCE (percent purity)	--	100%	95%	98%	--
Neat HCE for TCB $\mu\text{g/kg}$	--	<10	<10	<10	--
Neat TCB (clear) for HCE $\mu\text{g/kg}$	--	<10	<10	<10	--
Neat TCB (clear) for TCB (percent purity)	--	89%	87%	93%	--
Neat TCB (dark) for HCE $\mu\text{g/kg}$	--	--	<10	<10	--
Neat TCB (dark) for TCB (percent purity)	--	--	100%	95%	--
ENT Water HCE $\mu\text{g/l}$	Archived	Archived	Archived	<10	--
ENT Water TCB $\mu\text{g/l}$	Archived	Archived	Archived	<10	--
ENT fines	--	--	--	Archived	--

J. Indicates an estimated value. The mass spectral data indicates the presence of a compound, but the result is less than the quantitation limit, but greater than zero.

4. ENT Fines

The ENT fines sample was separated into its solid and liquid components. Both were found to be free of both POHC. The observed detection limit for the solids was 3600 $\mu\text{g/kg}$; as stated above, the liquid phase detection limit was 10 $\mu\text{g/l}$.

5. Method 5.

The samples obtained from the Method 5 train sample were analyzed for chlorides and particulates. ITAS Analytical Laboratory determined the chloride concentration of the sample train condensate and the quantity of particulate in the probe washes. The quantity of particulate collected on the M5 filter was determined at NCBC using a calibrated Satorius^R analytical balance.

6. POHC Characterization

A screening analysis for both POHCs was conducted before the trial burn to ensure that a quality product was purchased for the test and to ensure that the POHC input requirements were met. The TCB was determined to be essentially pure. The HCE from the original source was later unavailable; therefore the prescreening analysis on that HCE was to no avail. Due to time constraints, the final source of HCE was not prescreened.

The POHCs used for the trial burn were analyzed to determine their purity. Those data were necessary to accurately determine the POHC feed rate. TCB was analyzed for both TCB and any potential cross contamination of HCE. Similarly, HCE was analyzed for both HCE and any potential cross contamination of TCB. The lowest purity of HCE detected was 95 percent. The lowest percentage of TCB detected was 87 percent. Cross contamination of either POHC was not detected (detection limit of 10 $\mu\text{g/kg}$).

7. Ambient Air Samples

Upwind, downwind, and onsite ambient air Polyurethane Foam (PUF) samples were analyzed for HCE and TCB. All samples were found to be free of both POHCs. The observed detection limit for both POHCs was 10 µg/PUF. Based upon a nominal 24- hour sample collected at a rate of 10 ft³/minute, the detection limit is calculated to be approximately 0.024 µg/m³.

B. PERFORMANCE RESULTS

The NCBC trial burn was completed to provide information on incinerator performance, as discussed below. The input values and calculation results are presented in Table 14.

1. Destruction and Removal Efficiency (DRE)

40 CFR 264.343(a)(2) requires a DRE of 99.9999 percent (or greater) for systems processing F020 through F028 listed hazardous wastes. Because NCBC waste falls in this classification, a DRE of 99.9999 percent must be demonstrated in three replicate tests at operational conditions that will be maintained during processing.

The DRE is the percentage of the POHC mass rate not released at the incinerator stack. The DRE is generally expressed as a percentage and is calculated for this report using POHC mass rate units of grams per hour.

$$\text{DRE} = \frac{(\text{Mass Rate In} - \text{Mass Rate Out})}{\text{Mass Rate In}} * 100$$

DRE values are derived from the following parameters:

- POHC feed rate
- POHC feed concentration or purity

TABLE 14. NCBC TRIAL BURN PERFORMANCE RESULTS

	7A	7B	7C
General Data			
MM5 volume sampled dscf	125.812	128.751	132.578
Stack flowrate dscf/hour	479362	478576	495142
HCE Data			
MM5 concentration of HCE $\mu\text{g}/\text{sample train}$	<1.0	<1.0	<1.0
HCE POHC Purity	>95%	>95%	>95%
Mass of HCE out (grams/min) maximum	6.35E-05	6.20E-05	6.22E-05
TCB Destruction and Removal Efficiency	99.99997	99.999979	99.99997
TCB Data			
MM5 concentration of TCB $\mu\text{g}/\text{sample train}$	0.14	<1.0	<1.0
TCB POHC Purity (lowest value observed)	>87%	>87%	>87%
Mass of TCB in (grams/min)	197.316	197.316	197.316
Mass of TCB out (grams/min) maximum (see Note 1)	6.35E-05	6.20E-05	6.22E-05
HCE Destruction and Removal Efficiency	99.999968	99.999969	99.999968

TABLE 14. NCBC TRIAL BURN PERFORMANCE RESULTS (CONCLUDED)

	7A	7B	7C
Particulate Data			
Method 5 Filter Catch	46.3	90.4	95
Method 5 Probe Wash	27	35	180
Total particulate collected	73.3	125.4	275
Method 5 Volume Sampled	125.858	125.898	129.294
Average stack oxygen	5.8%	5.80%	5.60%
Particulate Loading corrected to 7% oxygen mg/dry standard cubic meter	18.94	32.39	68.28
HCl Emissions Data			
Chloride collected from Method 5 impingers (mg/train)	35	11	6
Stack flow rate measured by Method 5 train (dscfh)	460506	458125	467632
Chlorine emission rate (kg/hour)	0.117	0.040	0.022
Chlorine emission rate expressed as HCl (kg/hour)	0.121	0.041	0.022

Note:

1. The detection limit of 1.0 $\mu\text{g}/\text{sample train}$ was used for the DRE calculations because ITAS reported the 0.14 $\mu\text{g}/\text{sample train}$ as below detection limits, but greater than zero.

- Stack detection limits
- Stack gas flow rate
- Volume of stack gas sampled.

The minimum DRE for HCE was 99.99997 and the minimum DRE for TCB was 99.99996. Rounding of DRE values is not permitted by EPA.

2. HCl Emissions

40 CFR 264.343(b) requires that incinerators limit the output of HCl to no more than 1.8 kg/hour, or to no more than 1 percent of the HCl concentration entering the pollution control equipment if the 1.8 kg/hour limit is exceeded.

HCl emission values were obtained according to EPA M5, using a 0.1 N NaOH solution to trap chlorides for a specific volume of stack gas. The NaOH was analyzed by Titrametric Method 325.3 for total chlorides, and this result was then converted to a stack concentration at standard conditions.

HCl emissions averaged only 3.3 percent of allowable EPA release rates. During NCBC soil processing, the maximum chlorine available was expected to be less than one-tenth (1/10) that of the trial burn due to low relative chlorinated organic concentrations.

3. Particulate Loading

40 CFR 264.343(c) requires that an incinerator emit no more than 180 mg/dscm (0.08 grains/dscf) of particulate when corrected to 7 percent O₂.

Particulate loading was obtained according to EPA M5, using an appropriate filter and acetone rinse. The filter was desiccated and weighed by the sampling team on site, while the probe wash was evaluated by the analytical laboratory. The results from both sources were then arithmetically added, converted, and corrected to standard stack concentrations, as specified in 40 CFR 264.343(c).

The average loading for all tests was 39.86 mg/dscm, with the highest run producing 68.28 mg/dscm. The average value for all runs represents 22 percent of the 180 mg/dscm threshold for particulate in 40 CFR 264.343.

Process results can be found in Section VI.C.3.b.

4. Soil Removal Efficiency

The ability of the MWP-2000 to remove POHC from the soil is also measured by the soil removal efficiency which is given by:

$$\text{Soil Removal Efficiency} = \frac{\text{Min} - \text{Mout}}{\text{Min}} \times 100$$

where

Min = POHC feed rate in grams/minute

and

Mout = the detection limit or measured concentration of POHC in the processed soil leaving the kiln.

No POHC was detected in the processed soil with a detection limit of 330 ppb. The minimum POHC input rate was 197.5 grams TCB/minute with an average soil feed rate of 5.23 tons/hour. Therefore, the soil removal efficiency is at least 99.986 percent. Note that this is not to be confused with the destruction and removal efficiency which is determined at the effluent stack.

C. QUALITY ASSURANCE RESULTS

1. Process Results

a. POHC Feed Weight

As previously stated, the POHCs were transferred from the bulk containers in which they were received to small plastic containers that could then be introduced at the feed auger for the kiln. Each container was filled and checked to ensure that at least 1.5 pounds of POHC were placed in the container.

As a quality assurance (QA) check, 15 of each type of container (bags and bottles) were pulled out for a second weighing on the day of the run. The weights were recorded, and the results were presented in the Trial Burn Report submitted to EPA Region V. To enable determination of new weights of the POHCs in the containers, 15 of each type of container were weighed empty, and those weights are also included in the Trial Burn Report. For the sake of conservatism, calculations of POHC feed rates for the test runs were based on 1.5 pounds of POHC, even though the QA check confirms that the mean value of POHC in all containers is greater than this quantity.

b. Sand Feed Rates

As noted in Sections II and IV, the electronic input data from the weigh hopper to the DAS could not be used for the May 11 test run (Run 7A). The scale analog readings were recorded and used instead. For the succeeding runs, the DAS data were correct and were used. For comparison, the scale readings and the DAS results were, in tons per hour:

<u>Run Number</u>	<u>Scale Readings</u>	<u>DAS Data</u>
7B	5.217	5.3
7C	5.33	5.3

c. Stack Gas Analyzer Calibration

Before the first test run attempt, all three of the stack gas analyzers were given a three-point calibration. On days when the test runs were made, the analyzers were each checked for span and zero before and after each run. Since this period covered 9 days, the analyzers were under close scrutiny for the entire period. The only change made to any of the analyzers was that the fuel cell required changeout on the oxygen analyzer when the first cell was damaged by water in the sample. Each of the daily checks was witnessed by an EPA representative.

No appreciable drift was found on any of the analyzers. Each quality assurance element is presented below.

Accuracy is the difference between observed values and actual values for the daily calibration checks, as a percent of full scale. The following values were observed for the general test period:

<u>Analyzer</u>	<u>Average</u>	<u>High</u>	<u>Low</u>
Oxygen (%)			
Zero point	0.18	0.3	0.0
Operating point	5.11	5.3	5.0
Carbon Dioxide (%)			
Zero point	0.12	0.2	0.0
Operating point	10.13	10.2	9.7
Carbon Monoxide (ppm)			
Zero point	0.76	3	0.0
Operating point	26.8	25	30

Precision is the standard deviation of the sample readings. The following values were observed for the general test period:

<u>Point</u>	<u>Zero</u>	<u>Mid or Operating</u>
Analyzer		
O ₂	0.070	0.081
CO ₂	0.970	2.007
CO ₂	0.083	0.122

These are from the daily zero and span checks made, beginning with the calibration on May 7.

Combustor temperatures are sensed at each location by redundant thermocouples that have independent readout and recording capabilities. All permit-specified thermocouples were calibrated before the test runs.

2. Sampling Results

The QA/QC objectives, as they relate to sampling were met for this project and are discussed in Section V. The QAPP presented in the NCBC Trial Burn Plan was used as a guideline to ensure that all applicable QA/AC procedures were followed. In addition, an independent quality audit was also performed.

For the independent-quality audit, the following information was compiled for each sample before the trial burn:

- Sample type (background, grab, composite)
- Analysis to be performed (archives, HCE, TCB, particulates, chlorides)
- Sample container. The proper sample containers in which the samples were to be collected were identified

- Method of preservation. The proper method of preservation for each sample was identified.

As the samples were collected, the following information was also recorded for each sample:

- Sample number
- Cooler number. All coolers were identified with Versar cooler number labels
- Date and time sample was collected
- Date the sample was shipped.

The independent-quality audit was used to identify and track all samples taken during the trial burn. In addition, the proper analysis, sample containers, and method of preservation for each sample could be verified from the audit. The correctness and completeness of the Chain of Custodies were also verified against the information compiled in the audit.

3. Analytical Results

Overall effectiveness of a laboratory quality control program depends on systematically ensuring the precision and accuracy of analyses by detecting errors and preventing their recurrence, or measuring the degree of error inherent in the methods applied. The quality assurance objectives for precision, accuracy, and completeness are presented in Table 5, along with reference to analytical methods used and the matrices to which these methods apply.

The routine internal quality control program of the analytical laboratory included daily calibration of instruments using certified standards. Glassware was checked for cleanliness and for detergent removal before each analytical run. Pesticide quality solvents were used for trace

organic applications. Each lot of solvent was checked to ensure its suitability for the intended analysis. The highest commercially available purity standards were used for calibration.

The blank, analytical replicate, and spiked quality control samples were analyzed in the same way as field samples and interspersed with the field samples. The analytical results of these samples were used to document the validity and control the quality of data within predetermined tolerance limits.

The quality assurance objectives for this project were to provide reliable sampling and analytical data for documenting HCE and TCB concentrations in the feedstock soil matrix, treated residue, neutralization tank water, and stack gases for ENSCO's incinerator during treatment of the dioxin surrogate at NCBC.

One of the QA objectives for this project was that the percent relative standard deviation (percent RSD) of response factors from the initial calibration curve for the POHCs should be less than 30 percent. For each subsequent calibration check, the percent difference (percent D) between the mean response factor from the calibration curve and the response factor from the daily calibration should be less than 30 percent.

In this project, the percent RSD of response factors of the calibration check compounds was <30 percent. The highest value was 29.5 percent, with an average of 14.0 percent. The continuing calibration check found the percent difference between the mean response factor from the calibration curve and the response factor of the calibration check compound in the daily calibration <30 percent. The maximum value was 13.8 percent, with an average of 7.5 percent. (Average percent calculated using absolute values of percent, direction of deviation discounted.) The calculated values for each analysis day are presented in Table 15.

TABLE 15. CALIBRATION RESPONSE FACTOR RESULTS

<u>Date</u>	<u>Calibration</u>			
	<u>Initial</u> <u>(percent RSDs)</u>		<u>Continuing</u> <u>(percent Ds)</u>	
	<u>Maximum</u>	<u>Average</u>	<u>Maximum</u>	<u>Average</u>
5/6	28.7	17.7	--	--
5/8	--	--	24.4	15.8
5/15	20.3	7.9	--	--
5/19	--	--	16.	6.6
5/20	--	--	19.7	8.0
5/21	24.0	10.9	--	--
5/22	--	--	17.6	8.1

Each instrument used in this project was checked on each day that samples were analyzed to demonstrate performance. One of the QA objectives was that the absolute instrument response [e.g., area counts per ng injected for the internal standard(s) and/or surrogates in a GC/MS analysis] are within a factor of 2 (-50 to +100 percent) of the value of the last daily standard.

Another QA objective for this project was that the percent recovery for analysis of surrogate compounds in samples from a given waste stream be within the limits specified in the referenced methods. All system performance check compound recoveries and calibration check compound recoveries were within the limits specified.

In general, the accuracy goals for this project were to use reference materials of highest known purity for calibrations and spiking so that determinate errors due to instrument response and incomplete preparation recoveries could be identified, and so that any primary uncertainties in the analytical data were due to random errors not exceeding 5 percent.

A decafluorotriphenylphosphine GS/MS tuning and mass calibrations were run on the date every calibration standard blank and associated samples were run. All ion abundance criteria were met.

The number and frequency of all reagent, method, and field blanks follow guidelines set forth by the laboratory's QA/QC plan. All blanks were analyzed by the appropriate method (see Table 12) and were found to be free of any POHCs.

The recoveries of trichlorobenzene and hexachloroethane were within the range presented in the quality assurance objectives for all spike and spike duplicate samples, except one. The recovery of trichlorobenzene

in a site-spiked sand sample (DD0781D) was 33 percent, outside the 14-to 142-percent range. When the same matrix was spiked by the laboratory, the percentage recovery was found to be 88 percent (within the quality assurance range).

All quality assurance objectives set forth by the laboratory were met.

VII. POST-TEST REGULATORY INTERACTION

As discussed previously, the Air Force agreed to do a full-scale trial burn to demonstrate the required 99.9999 percent DRE. That agreement was made with the verbal understanding that EPA Region IV staff would expedite the review of the trial burn report so that full-scale operations could commence at the earliest possible time. The Air Force sought this agreement in an effort to minimize the exorbitant costs associated with potential extended delays while awaiting regulatory approval to commence operations.

A. INITIAL REQUEST FOR ADDITIONAL TECHNICAL INFORMATION

On June 9, 1987, following the trial burn, the Air Force received a formal request from EPA Region IV concerning a variety of technical issues. - The EPA questions and the response written by EG&G Idaho are presented in Appendix E. In the June 9 request, the EPA requested that the Air Force develop an ambient air monitoring program for routine operations. Although ambient air monitoring was conducted for the verification test burns and the RCRA trial burns, such a monitoring program had not been developed for routine operations.

The June 9 EPA letter also requested:

- clarification of the use of a Thermal Relieve Valve, which is a device located between the SCC and the boiler and is used in an emergency condition to divert heat away from the boiler.
- clarification of the calculation method for SCC combustion gas retention time.
- the method of measuring solids feed rate to the kiln.

These issues required clarification in order for EPA to set the permit operating conditions. The second two items caused a considerable amount of work because neither of those systems had been adequately developed by ENSCO, the incinerator subcontractor. The response to those requests was sent to EPA on September 2, 1987.

B. TRIAL BURN REPORT COMMENTS

Following the trial burn in May 1987, EG&G Idaho wrote a trial burn report with the assistance of Versar and the U.S. Air Force. ENSCO also provided some technical information for the trial burn report. Before commencement of extensive work on the report, EG&G Idaho discussed the report outline with the persons within EPA Region IV who would review it. Once an outline was agreed upon, a draft trial burn report was submitted to - EPA Region IV on June 16, 1987. The transmittal letter requested that EPA quickly review the draft for general format and content. This request was made to again ensure that the report authors were working in a direction that was compatible with EPA needs and requirements. EG&G Idaho was also striving to present a report that would be easy for the regulating agencies to review in the hopes of expediting the review process.

EPA thoroughly reviewed the draft report and submitted verbal comments to EG&G Idaho in early July, 1987. The comments were incorporated and the final trial burn report was submitted to EPA Region IV on July 15, 1987, eight weeks after the completion of the trial burn. EPA Region IV subcontracted much of the technical review.

In late August, 1987, EPA Region IV submitted their formal comments concerning the trial burn report to the Air Force. Most of those comments requested additional information or clarification concerning quality assurance issues. EPA Region IV agreed that the MWP-2000 had passed the 99.9999 percent DRE requirement; however, they were still uncertain on what permit operating conditions to set. In particular, the issue of how to accurately measure and regulate the mass feed rate was raised again. All of their comments, except the mass feed rate, were addressed, and a formal

response was submitted to EPA Region IV on September 9, 1987. (The mass feed rate issue is discussed below.) The EPA questions concerning the trial burn report and the formal response are presented in Appendix F.

C. AMBIENT AIR MONITORING PLAN

The September 2 transmittal to EPA Region IV included a conceptual ambient air monitoring plan for routine operations. That draft called for background sampling before commencement of routine operations. Once operations began, the draft plan called for continuous 24-hour monitoring using three PUF samplers and two high-volume particulate samplers. The action level for EPA notification and cessation of excavation was 3 pg/m^3 .

EPA reviewed this draft plan and provided verbal comments in several telephone conversations in September, 1987. A final ambient air monitoring plan was submitted on October 7, 1987. That plan called for five PUF samplers at four distinct locations. The samplers were to be located: (a) upwind of excavation, (b) near the point of excavation, (c) at the nearest downwind HO storage area boundary, and (d) at a point 150 meters downwind of the nearest HO site boundary (or the NCBC base boundary, whichever is closer). The fifth sampler was used for quality assurance purposes. Additionally, two high-volume air samplers and an optical particle counter were to be used at the upwind monitoring station and at the HO site boundary station to determine total particulate concentrations resulting from excavation activities and naturally present in the background air.

During the development of the final ambient air monitoring plan, EPA verbally requested that the monitors be run continuously, 24 hours per day, even if no excavation was occurring. The Air Force and its contractors discouraged continuous monitoring during periods of nonexcavation because such monitoring would mask and dilute the potential effects of excavation. Nevertheless, at the insistence of EPA Region IV, continuous monitoring was implemented during the initial phase of routine

operations. The plan also called for a data review after 30 days of monitoring. That review was to determine if a reduction in monitoring was appropriate or if other modifications were necessary. As discussed in Reference 4, the plan was modified in March, 1988 to reduce the overall monitoring requirements. Specifically, the plan was modified, with EPA approval, to eliminate the requirement for sampling during periods of nonexcavation; after March 1988, sampling was conducted only during excavation.

D. MASS FEED RATE

The issue of accurately monitoring and regulating the solids feed rate to the kiln began during the trial burn and continued after the commencement of routine operations. During the trial burn, the mass feed rate was measured by determining the weight loss of the weigh hopper over a specified period of time. Load cells on the weigh hopper were linked to the DAS that recorded the weight every 6 seconds. An algorithm in the DAS converted the load cell readings to mass feed rate in terms of tons per hour. The variability of load cell readings due to wind and shifting soil in the hopper over a 6-second interval is very wide. Therefore, an averaging system was also structured into the DAS algorithm to smooth the data and make them comprehensible. Additionally, there was concern about the lag time between the moment when soil was measured in the weigh hopper and the moment when it actually entered the kiln through the feed auger, approximately 2 minutes later.

In late September 1987, an attempt was made to correlate the mass feed rate measured by the weigh hopper and DAS to the feed auger speed. It was believed that a maximum auger speed limit could be used to ensure that contaminated soil would not be fed to the incinerator in excess of the rate observed during the trial burn. No accurate correlation was possible because of variabilities in soil moisture and density. Therefore, EPA Region IV verbally agreed to set the mass feed rate at 5.3 ton/hour based upon the weigh hopper load cells and the DAS. However, EPA Region IV also stipulated that the Air Force would attempt a

correlation between mass feed rate and auger speed using operational data collected during the first 15 days of soil processing. Those data were collected, but again, no accurate correlation could be drawn. The wear of the auger flights would also have a significant effect upon any such correlation; as discussed in Reference 3, the auger flights wore significantly; several replacement augers were installed throughout the project.

E. SCC RETENTION TIME

The SCC retention time is measured to assess the completeness of combustion of the process off gases. If the retention time is too short, the products of combustion from the kiln may not be fully combusted upon leaving the SCC. Extremely long retention times may cause process inefficiency. As a permit-specified condition, the EPA set the retention time during normal operations to be greater than the retention time observed during the trial burn.

The retention time in the MWP-2000 secondary combustion chamber was calculated as a function of: (a) the total natural gas flow rate (SCC and kiln), (b) SCC and kiln combustion air flow rate, (c) SCC and kiln temperature, (d) soil feed rate, and (e) the volume of the secondary combustion chamber. Additionally, certain assumptions, including the air leakage into the kiln via the kiln seals and the soil moisture content, were inherent assumptions to the original calculation.

One of the comments in EPA's letter of June 9 requested clarification of the retention time equation presented in the trial burn. That question prompted a reevaluation of the original equation. ENSCO submitted a revised equation that was, in turn, transmitted to the EPA on September 2 (Appendix E). Although that equation was an improvement over the original, it still contained certain unverified and unmeasurable assumptions concerning the air leakage rate and soil particulate carryover rate from the kiln to the SCC.

Several additional questions in conversations with EPA Region IV prompted another review of the retention time calculation. That review resulted in a substantially different equation that did not have unmeasurable or unverified assumptions. The new equation was a function of: (a) the kiln and SCC temperatures, (b) the kiln and SCC natural gas flow rate, (c) the stack gas oxygen content, (d) the solids feed rate, and (e) the soil moisture content.

$$RT = \frac{(1378.9 \text{ ft}^3) (3600 \text{ sec/hour})}{\left[\frac{(T_{SCC} + 460)}{520} \right] \left[CH_4 \left(\frac{CH_4 \cdot O_2 \cdot 2}{21 - O_2} \right) \left(\frac{CH_4 \cdot 158.0}{21 - O_2} \right) (CH_4 \cdot 2) \right] \left[\frac{(T_{SCC} + 460)}{672} \right] \left[\left(\frac{SM \cdot 26.799}{100} \right) + (S \cdot .232 \cdot 26.799) \right]}$$

Equation 1

where:

- S = Solids feed rate, lbs/hr
- M = Soil moisture content, percent
- T_{SCC} = Secondary combustor temperature °F
- CH₄ = Natural gas flow rate in both the kiln and the SCC, Standard ft³ per hour
- O₂ = Oxygen content of stack gas, percent
- 1378.9 = Internal volume of SCC, ft³

Process data for those parameters were resubmitted along with the revised calculated retention time. Those data had been collected at 5-minute intervals during the trial burn tests. Graphs for the new retention times were also provided. (See Appendix G for those data.) EG&G Idaho proposed that the permit specified retention time be set at 1.60 seconds, the minimum value observed during the three tests. EPA chose to be more conservative and set the retention time at 1.65 seconds.

F. ASH DISPOSITION AND ANALYTICAL REQUIREMENTS

Because the contaminated soil at NCBC contained 2,4,5-T, a herbicide that had trace quantities of dioxin, it was considered an F027-listed hazardous waste. When such a waste is thermally processed, RCRA regulations consider the ash produced as an F028-listed hazardous waste. Therefore, the waste must be disposed as a hazardous waste in an approved Subtitle C landfill.

Alternatively, if the producers of the waste believe that the waste is not a threat to human health or the environment, they may petition the EPA Office of Solid Waste to remove the particular waste from its list of hazardous waste. This process is called delisting. Once a waste is delisted, it no longer falls under the jurisdiction of RCRA.

At the time of project initiation, no Subtitle C landfills in the United States could accept an F028-listed waste. Therefore, the only disposal option available to the Air Force was delisting. Additionally, EPA was not granting up-front delisting at that time; that is, they required substantial analysis of the waste before they would make a delisting determination.

At the beginning of the project in early 1986, the Air Force recognized that the delisting regulations could seriously impact the disposition of the process ash. Therefore, the Air Force negotiated an agreement with the EPA Region IV regional administrator that allowed the process ash to be backfilled onsite before the submission of a delisting petition. To backfill the ash, the concentration of TCDD, total chlorinated dioxins, and total chlorinated furans had to be measured and determined to be each less than 1.0 ppb. The process ash was to be collected in batches in rolloff bins. Each batch was to be sampled to determine that it met the aforementioned criteria before backfilling. If the batch did not meet the criteria, then it was to be reprocessed in the incinerator.

Following the trial burn, project personnel realized that the volume of process ash expected to be produced would far exceed the roll off bin capacity available at NCBC. Therefore, an alternate ash storage arrangement was developed that would employ ash bins constructed of railroad ties and lined with heavy plastic. This change in temporary ash storage plans was submitted to the EPA on October 18, 1987. EPA found this plan unacceptable as a minor permit modification; however, the EPA would allow the Air Force to use the alternate plan following a 45-day public comment period. Due to the potential for an extended delay caused by the change in ash storage, the Air Force decided to withdraw that plan and return to the use of rolloff bins (Appendix H).

In October 1987, after all of the questions concerning the trial burn report and the incinerator operating conditions were nearly fully resolved, EPA Region IV staff began to question the ash backfilling plans and suggested that such action would not be permitted. The Air Force and its contractors evaluated several options, including a large storage bunker for the process ash, but quickly concluded that storing such a large volume of waste until a delisting determination was made by EPA Office of Solid Waste would be financially unfeasible.

Additionally, EPA Region IV reexamined the daily analytical requirements for the process ash. The RD&D permit previously issued by the EPA had specified that TCDD, total chlorinated dioxins, and total chlorinated furans be measured using EPA method SW 846-8280, which is a low resolution GC/MS technique with a detection limit of approximately 0.1 ppb. In November, EPA Region IV staff considered requiring daily ash analysis for dioxins and furans using high-resolution isomer specific techniques (detection limit 1.0 ppt) in addition to analysis for a variety of other organic and inorganic analytes. This proposal would have significantly inflated the cost of the project. These issues were at a stalemate between the Air Force contractors and the EPA Region IV staff. Therefore, the Air Force project officer met with the EPA Region IV administrator to negotiate a compromise. That meeting resulted in continued permission to backfill the

treated soil pending analysis demonstrating that the 2,3,7,8-TCDD, total TCDD and total TCDF concentrations were below 1.0 ppb. Additionally, the Air Force agreed to perform a comprehensive analysis on a 24-hour composite sample collected once per month.

G. RESULTING RD&D PERMIT CONDITIONS

As a result of the data from the trial burn and the ensuing communications and negotiations, EPA Region IV set the operating conditions for the NCBC full-scale demonstration project. Those operating conditions are summarized in Table 16.

TABLE 16. NCBC FULL-SCALE DEMONSTRATION PROJECT FINAL
RD&D PERMIT OPERATING CONDITIONS SUMMARY
(as of November 23, 1987)

-
- The incinerator must meet a 99.9999 percent destruction and removal efficiency.
 - Hydrogen chloride (HCl) emission rate must be less than 1.8 kilogram/hour or 1 percent of the HCl in the stack gas before entering any pollution control equipment
 - Particulate matter must not exceed 180 milligrams per dry standard cubic meter corrected to 7 percent oxygen.
 - Mass feed rate <5.3 tons/hr
 - Kiln temperature >1450°F
 - SCC temperature >2150°F
 - SCC retention time >1.65 seconds
 - Stack carbon monoxide cannot exceed 50 ppm for more than 6 minutes
<500 ppm maximum at all times
 - Maximum auger speed 5.8 rpm
 - Packed-tower recirculation flow rate >132 gallons/minute
 - Ejector scrubber recirculation flow rate >35 gallons/minute
 - Kiln Pressure Cannot exceed -0.05 inches of water for more than 15 seconds

TABLE 16. NCBC FULL-SCALE DEMONSTRATION PROJECT FINAL
RD&D PERMIT OPERATING CONDITIONS SUMMARY (CONCLUDED)

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- Thermal Relief Valve To be opened only under emergency conditions when steam drum water level is at 0 percent, the waste heat boiler exit temperature exceeds 600°F, or the packed tower inlet temperature exceeds 220°F. SCC temperature must be maintained for approximately 20 minutes with the kiln rotation at 4.5 rpm or until all material in the kiln is removed.
 - A report attempting to correlate the bulk average feed rate to the auger speed for the first 14 days of operation shall be submitted to the regional administrator.
 - Ambient air shall be monitored per the ambient air monitoring plan until the regional administrator approves of proposed changes to be submitted approximately 30 days after the startup of operation.
 - Soil moisture must be measured via an infrared analyzer or ASTM method 02216-80 and the data shall be input to the DAS each 8-hour shift. A correlation shall be drawn between the automatic infrared analyzer system and the ASTM method and reported to the regional administrator within 5 days of commencement of operation.
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VIII. EVALUATION AND DISCUSSION

This section summarizes the results of the RCRA trial burn tests at NCBC and discusses the performance of the MWP-2000 incinerator system. Significant problems encountered during the trial burns are identified and discussed in terms of their potential impact on incinerator performance at the NCBC site and other hazardous waste sites.

A. INCINERATOR PERFORMANCE

The NCBC trial burns were performed to determine compliance with three major criteria specified in 40 CFR 264.343. Tables 7 and 8 summarize the incinerator performance and the performance criteria. All three tests met all three criteria.

The trial burns were also conducted to determine the operating conditions to be maintained during normal operations. Table 16 in Section VII summarizes the specified operating conditions.

B. SOIL TREATMENT

The production of noncontaminated process ash was not a goal of these tests. The RCRA regulations for incinerator performance do not specify that the waste product meet specific criteria. However, if an incinerator process produced a contaminated waste, it would be regulated as a hazardous waste. Therefore, it behooves persons performing a RCRA trial burn to not only strive to produce a clean off gas, (i.e., meet the 99.9999 percent DRE), but also to strive to produce a waste product that can be easily disposed or delisted.

The trial burns performed in May 1987 at NCBC processed clean sand at a feed rate of 5.3 tons per hour while also processing two POHCs that were fed into the incinerator in discrete containerized quantities at the rate of 1.5 pounds/minute each. The two POHCs were 1,2,4-trichlorobenzene and hexachloroethene.

No POHC was observed in the process ash at detection limits of 330 ppb. Therefore, the soil removal efficiency of the incinerator is at least 99.986 percent; higher efficiencies are likely if lower analytical detection limits are used.

Despite the fact that neither POHC was detected in the process ash, EPA considered the waste a listed hazardous waste. Therefore, the processed sand used during the trial burn had to be disposed as hazardous waste in an approved Subtitle C landfill. Alternatively, a petition could have been submitted to EPA to request that the waste be delisted. Due to the relatively small volume of waste and the anticipated cost and delay to obtain a delisting determination, it was deemed less costly to dispose of the waste produced during these trial burns.

The ENT water and fines were sampled after the final run (7C) and was determined to be free of POHC (detection limit 10 ppb).

Because no POHC was found in any of the waste streams, the MWP-2000 incinerator has been shown to be able to effectively destroy highly refractory POHC.

C. PROBLEMS ENCOUNTERED DURING TESTING

Numerous problems were encountered during testing and preparation. The financial contracts between EG&G Idaho and the subcontractors were cost-plus-fixed fee arrangements; this means that all legitimate costs incurred by the subcontractors would be paid by the Air Force in addition to a fixed amount of profit. (EG&G Idaho held the contract with Versar and ENSCO; the Air Force was EG&G Idaho's funding source.) The cost for each day of operations, including labor and incinerator equipment lease rate, was approximately \$25,000 per day. Many of the decisions made, and the haste with which this project was conducted, was driven by the high cost for each day of operations. Other specific problems encountered are discussed below.

1. POHC Availability

The availability of POHC significantly affected the trial burn. The unavailability of hexachlorobenzene delayed the project approximately two weeks while contractor personnel searched in vain for an adequate source of the compound. Additionally, the initial supplier of HCE was unable to deliver in time for the trial burn. Although an alternate source was found, premium charges were incurred for expedited procurement and transport of the compound. The delivery of HCE did not significantly affect the overall test schedule.

2. POHC Mixing

The trial burn plan called for mixing the two POHCs with the clean builders sand in a cement mixer. That method of POHC mixing was not feasible. Significant amounts of POHC were lost during mixing and the POHC concentration in the mixed sand was too low to demonstrate the required 99.9999 percent DRE. An alternate method of POHC addition was developed and accepted by the EPA. That method added discrete 1.5 pound quantities of each POHC directly to the feed hopper and proved to be a very convenient method of POHC addition.

The POHC mixing problems caused approximately a 1-week delay until an alternate mixing plan was developed. During that time several methods were tried to mix the POHC into the sand. Following each experiment, a sample was collected and air-freighted via Federal Express delivery to ITAS Analytical Laboratory for analysis. On one occasion the experiment was completed on Sunday, May 3, 1987. Because Federal Express does not collect packages on Sundays, and because there were no local analytical laboratories on contract, an air taxi was chartered to fly the samples from Gulfport, Mississippi to ITAS Analytical Laboratories in Knoxville, Tennessee. The expense of the air taxi was insignificant compared to the cost of waiting an additional day for normal air freight delivery.

3. Stack Testing

Numerous problems were encountered during the stack testing. One of the preventable delays was caused by poor maintenance of the testing equipment. A badly worn "O" ring on a quick-connect fitting caused the pretest leak check to fail to meet the specified criteria. A substantial amount of time was spent to determine the cause of the leak, and a full day of testing was lost.

Additionally, one of the glass probes used for stack testing was cracked. The crack was detected in the middle of the test when the traverse direction was changed. The isolation of that leak was quickly determined and a second probe was used for the second half of the test. Both probes were washed and the probe wash water was combined for analysis. The potential existed for substantial delays; however, no significant delays were actually incurred for this failure.

Another test attempt failed because a technician spilled the probe wash during the posttest data recovery procedure. As a result, that test had to be repeated. This failure resulted in a one-day delay.

Another test was rejected in the field because it was discovered that the XAD module on the MMS train was installed upstream of the condenser. Normally, the XAD module is installed downstream of the condenser. There was no assurance that adequate POHC collection occurred on the XAD module because the gas temperatures entering the XAD module were higher than normal. This failure caused one lost day of testing.

4. Weather

Weather was a prime culprit of the delays experienced during NCBC trial burns. In May, Mississippi weather often brings afternoon thunderstorms. Safety considerations precluded stack sampling during thunderstorms because of the flat terrain and large steel structure around the stack and the incinerator. Approximately 3 days were lost due to the weather.

5. Analytical Detection Limits

Before analysis, an engineer reviewing some trial burn planning documents discovered that the analytical detection limits to be used by ITAS were not sufficient to demonstrate the required 99.9999 percent DRE. To resolve the problem, ITAS was contacted to determine if their detection limits could be improved; a ten-fold increase was required. Although ITAS was able to achieve the lower detection limit, a day of testing was lost while the problem was solved. The root cause of this problem relates to insufficient staff and hasty planning, which allowed simple calculations to be insufficiently reviewed.

6. Trial Burn Planning

The planning for the trial burn was conducted over an extraordinarily short time period with limited staff. This caused many of the problems encountered during the trial burn because sufficient attention was not given to important details, such as the POHC mixing, the analytical detection limits, and the stack testing equipment maintenance.

7. Weigh Hopper Digital Scale Anomaly

An electrical power surge, as the result of a lightning strike on May 10, 1987, was suspected of corrupting the programmable electronics on the digital weigh hopper scale. This scale was linked to the DAS and provided input feed rates (in tons per hour) at 5-minute intervals. Although the electronic scale weighing mechanism was not affected, the programmable electronic circuitry linked to this mechanism provided values to the DAS that were not tons per hour and were clearly inconsistent with other known feed rate parameters (manual scale, auger speed, etc.). The anomaly was identified and reported by the system operators during the May 11 run. Because the digital scale could not be corrected during the run, the backup analog scale was used for this day. The analog scale is a Thurman^R mechanical type; all feed rate data presented for the May 11 test were based on this scale.

While the digital scale was known to be inaccurate, the DAS continued to store mass feed-rate values throughout the test. Because the extent of the problem was somewhat unclear, and with the potential that the 5-minute feed-rate values might have been helpful, DAS data were retained from Run 7A. The DAS values were later determined to be essentially meaningless and have been deleted from the data log.

The digital scale was reprogrammed and checked on the evening of May 11, and no further anomalies were encountered. The DAS readings for the May 12 and May 16 runs correlated to within 2 percent of the scale readings.

8. Single Triplicate Test

The trial burn was planned to consist of two sets of triplicate tests. The first set was to be conducted at a nominal feed rate of 4.0 ton/hour, and the second set was to be conducted at a nominal feed rate of 5.0 ton/hour. After initial runs were determined to be unacceptable because of excessive MM5 leakage and breakage, the test plan was modified to have only one set of three runs at a nominal feed rate of 5.3 tons/hour. Preliminary results from the test, in which the probe rinse was spilled (see item 4 above), indicated that the MWP-2000 could pass the 99.9999 percent DRE.

Additionally, preliminary results from the first two tests were received before conducting the third test. Those results indicated that runs 7A and 7B had passed the 99.9999 percent DRE requirement. With that data, project coordinators were highly confident that the third test would be equally successful. Furthermore, based on operational experience from the December 1986 verification test burns and these trial burns, operations personnel determined that significantly higher soil feed rates would not be likely. Therefore, testing at a higher feed rate was not deemed cost effective.

IX. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

A RCRA trial burn was conducted at the NCBC in early May 1987. The trial burns were conducted to support the mobile rotary kiln incinerator system. The incinerator was owned and operated by ENSCO, Inc. with project management and technical assistance provided by EG&G Idaho. Sampling was performed by Versar, Inc., and analysis of all samples was conducted by IT analytical Services..

A mixture of clean builders sand spiked with known quantities of 1,2,4-trichlorobenzene and hexachloroethane was used to test the performance of the MWP-2000 incinerator. The two POHCs were chosen because they represented a highly refractory material that is more difficult to incinerate than 2,3,7,8-tetrachlordibenzodioxin that was to be processed during normal operations. Clean builders sand was chosen as the surrogate solid matrix for its cleanliness, ease of handling, and similarity to the native NCBC soil.

Native contaminated soil was not used for these trial burns because the organic contaminant concentration was not sufficient to demonstrate compliance with the RCRA requirements. Additionally, EPA Region IV specifically denied permission to process any F027-contaminated waste until the RCRA incinerator requirements had been demonstrated.

Specific conclusions concerning the incinerator process performance and operational problems are described below.

1. The MWP-2000 exceeds the incinerator performance requirements specified in 40 CFR 264.343. Specifically:

- DRE was shown to exceed 99.99996 percent. The highest DRE observed was 99.999979 percent.

Higher DREs may have been possible if lower stack gas analytical detection limits were used. The DRE required to process F027-contaminated waste is 99.9999 percent.

- The highest particulate concentration observed was 68.28 mg/dscm. The RCRA requirements specify that the particulate concentration be less than 180 mg/dscm. Therefore, the MWP-2000 incinerator surpasses the particulate emissions standard by at least a factor of 2.6.
 - The highest hydrogen chloride (HCl) emission rate for these tests was 0.121 kg/hour. The applicable standard requires that the HCl emissions be less than 1.8 kg/hour, or less than 1 percent of the HCl input to the scrubber system. Therefore, the MWP-2000 surpassed the HCl requirements by a factor of 14.8 when processing the surrogate mixture. The chlorine loading during the trial burns was significantly higher than the chlorine loading projected for routine operations.
3. Numerous problems were encountered during the trial burn and its preparation. Notably, the originally planned POHC mixing technique was abandoned for direct addition of POHC to the incinerator. Problems during sampling centered around failure of MM5 leak checks.

All of the problems encountered were either personnel-related or temporary mechanical failures rather than a technical failure of the incinerator system.

B. RECOMMENDATIONS

1. This trial burn was required to demonstrate compliance with 40 CFR 264.343. In early 1986, ENSCO performed a trial burn on a twin sister unit located in El Dorado, Arkansas. The data from those tests were intended to be used by the Air Force in lieu of a trial burn at NCBC; the verification test burns conducted in December, 1986 at NCBC were only intended to demonstrate that no hazardous effluents would be emitted from the MWP-2000 when processing native contaminated NCBC soil. When EPA Region VII did not certify the El Dorado trial burns as meeting the 99.9999 percent DRE requirement, EPA Region IV justifiably insisted that the Air Force demonstrate DRE compliance before operations.

Therefore, future users of hazardous waste technologies are reminded to carefully examine certification data and to verify with the appropriate regulating agencies that the technology meets all applicable requirements. If the chosen technology does not meet the requirements, then the users should be prepared for extensive testing, technology development, and regulatory involvement.

2. The redevelopment of the residence time equation caused considerable delays in obtaining regulatory approval to commence operations. Therefore, when submitting a trial burn plan, all data that will be used to set operating parameters for normal operations should be clearly defined before testing.

For example, the method of calculating residence time was inadequately developed at the time of the trial burn. The residence time calculated during the tests was highly inaccurate and only coincidentally represented the actual SCC residence time. The inadequacy was not discovered and corrected until the trial burn report was thoroughly reviewed. Although data existed that enabled project personnel to recalculate the residence time, critical data needed for the calculation might not have been measured.

Because residence time is a critical operating parameter, such an oversight could have caused the complete failure of the trial burn test results.

3. Measurement of solids feed to an incinerator or other processes can be accomplished in a variety of ways. The method used at NCBC employed load cells that measured the weight of a hopper at a given time. The DAS differentiated those data to obtain a mass-feed rate. At the time of testing, project personnel and EPA regulatory personnel had a poor understanding of the data collection and differentiation system used. As a result, there was a considerable delay following the trial burn to properly explain and present the mass-feed-rate data.

Future users of this technology are encouraged to understand and thoroughly test the mass-feed system and its measurement and controlling devices.

4. The POHCs used for the NCBC trial burn were 1,2,4-trichlorobenzene and hexachloroethane. Those POHCs served the purpose very well and were reasonably easy to handle. HCE, however, is an Appendix VIII-listed hazardous waste; therefore, the ash resulting from the trial burns was also considered a listed hazardous waste. Future trial burn planners are encouraged to obtain a POHC that meets the technical requirements of the planned test and that will not result in a hazardous waste when processed. Substantial residue disposal costs or delisting documentation costs could be saved if the product was not hazardous.

5. Introduction of the POHC to the incinerator is an integral part of a trial burn. Direct addition of the POHC to the feed hopper worked extremely well for the NCBC trial burn, whereas the attempt to mix the POHC with the sand in a cement mixer was very unsuccessful. Future trial burn planners are discouraged from premixing the POHC with a solid matrix. Direct addition of the POHC to the feed system greatly simplified POHC handling and input calculation.

6. Future trial burn planners are encouraged to employ persons with demonstrated successful experience with trial burns and to ensure that they are adequately supported by other technically competent personnel. Although this trial burn was successful, many errors were encountered that could have been avoided if the planning team was properly staffed and supported. The principal planners for this trial burn included three engineers working for the prime contractor (all with masters degrees) and one technically degreed-Air Force Project officer. None of the planners had previously been involved in an RCRA trial burn. Additionally, very little engineering support was received from the incinerator subcontractor.

The development of the draft trial burn plan was conducted over a 7 day period. Following EPA review, the revisions to the plan were incorporated over a 21-day period.

Complex tests cannot be competently accomplished in such a short time period with such limited staff. Future trial burn planners are encouraged to at least double the staff and the time that was used for these tests.

7. Numerous problems were encountered during stack testing. Most of those problems were caused by high leak rates in the Method 5 and Modified Method 5 sample trains. A strong preventive maintenance program could have prevented some of the delays caused by the high leak rates. New glassware with tightly fitting joints and routine inspection of all sampling components could have substantially reduced the leakage problems.

8. Although nothing can be done to control weather influences, action can be taken to reduce its effects. Test planners should consider the local weather and include an appropriate amount of time for weather delays in the test plans. Additionally, if shelters around the stack sampling ports can be constructed, then sampling may continue during adverse weather. During thunderstorms, however, safety precautions should preclude anyone from being on elevated steel platforms, which are very typical of most stack sampling areas.

9. Based upon the analytical data from the NCBC trial burns, the MWP-2000 should be considered an acceptable technology for future hazardous waste remediation. This process is advantageous because it can process soil and other inorganic solids with little pretreatment. Additionally, it uses conventional and readily available equipment.

10. To ensure a successful trial burn, future test planners are encouraged to ensure that the incinerator operators and sampling team are well trained and have experience with the particular waste matrix or a suitable surrogate.

Test planners should ensure that all data acquisition instruments are calibrated and operable. Procedures should be in place to test and calibrate all critical equipment. The incinerator and complete DAS should be fully operable before the arrival of sampling contractors and at the beginning of the tests.

At least 1 week before the beginning of the test, the test planners should conduct a detailed operational readiness review meeting. That meeting should include competent and informed personnel from all disciplines involved in the test. During that meeting, all critical components and subsystems should be evaluated. If problems exist that would jeopardize the test, then a plan of action should be developed to solve the problem and test the component before the test.

Additionally, before each test day, a less comprehensive meeting should be conducted to ensure smooth coordination between the sampling team, the operations team, and project management. The site safety representative should be in attendance at those meetings.

Following each test, a "tail gate" meeting should be held to discuss any problems that developed during the test and how they were resolved. The attendees should discuss methods of how to avoid or solve the problem during subsequent tests.

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